

# **Enhancing Home Based Care for HIV patients using an Advisory Expert System**

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## Abstract

South Africa has one of the highest Human Immunodeficiency Virus (HIV) prevalence rates in the world. People living with HIV/AIDS experience many unrelieved symptoms. Nutritional care and support are important in preventing development of nutritional deficiencies. Home remedies can extend and improve the quality of their lives. Home remedies treatment involves eating healthy food, avoiding certain types of foods, psychological and emotional support and practicing hygiene to avoid skin infections (Sizani, Bandile; Nikiwe 2012). HIV/AIDS treatment and management strategies require ongoing management and support.

In this research, we work with people from a clinic in Gugulethu Township in Western Cape, South Africa. The area has high prevalence of HIV (Ministry of health South Africa 2011). Most of the HIV patients in this area access medical information by walking long distances to the clinic. Most of these patients are poor and sometimes cannot afford to visit the clinic regularly for medical advice. In this township there is scarcity of health care workers (HCWs). The HCWs toil on many fronts to meet the enormous demand for the HIV/AIDS services but they are not able to meet the patients' needs.

The aim of this research is to empower HIV-patients to self-manage the HIV-related symptoms which they experience. We investigated the way in which the HCWs deliver information to the patients. We interviewed the patients to understand what measures they take to manage the symptoms which they experienced. Consequently, we developed an advisory expert system to enhance Home-Based Care for HIV patients. An advisory expert system is defined as a computing system which is capable of representing and reasoning about some knowledge-rich domain, with a view to solving problems and giving advice (Gustafson et al. 1994).

Since South Africa has high mobile phone penetration and most of the patients own them, we opted to use mobile phone as a tool to access the information provided by the advisory expert system. The system was then deployed at the clinic. We trained both HCWs and patients how to use the system. The findings were captured and reported after a six month deployment of the system. The results show that our system can be used as an effective tool to disseminate nutritional and psychological support information to HIV- patients in Gugulethu. The system is simple, yet practical. It helps the patients to self-manage the HIV-related symptoms which they experienced and at the same time, saves time and cost for both HCWs and the patients.

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## List of Acronyms

AIDS	Acquired Immunodeficiency Syndrome
HIV	Human Immunodeficiency Virus
PLWHA	People Living with HIV and AIDS
HCWs	Health Care Workers
UN	United Nations
ICT4D	Information and Communication Technology for Development
ICT	Information and Communication Technology
NGO	Non-Government Organization
UCD	User Centered Design
HBC	Home Base Care
PCs	Personal Computers

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# **Chapter 1 : Introduction**

## **1.1.Introduction**

Human Immunodeficiency Virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS) is a major global health problem. It is also the greatest threat to the reconstruction and development of South Africa (Horton 2004). In 2011, the prevalence rate for HIV was estimated to be 10.6 percent and the total number of people living with HIV/AIDS rose from 4.2 million in 2001 to an estimate of 5.4million in 2011 (ASSA 2011). It has been estimated that up to 90 percent of nursing care is provided at home by the untrained family and associates (Avert 2011). Up to 80 percent of HIV/AIDS related deaths occur at home (Avert 2011). The patients and their care givers do not always have contact with adequate professional help. This is as a result of health clinics being far away from their vicinity, lack of transportation means in the region, lack of funds to pay for transportation and poor infrastructure (Schoeman S MA CUR; Smuts CM, PHD; Faber M, PHD; Oelofse A, PHD; Laubscher JA, Bcom; Beanade AJS, PHD; Dhansay MA 2010).The South African government is providing clinical support to handle the complexity and incurability of HIV/AIDS. In addition to this, more funds have been allocated to facilitate the development of more computer based systems to help manage the HIV/AIDS pandemic (Shaw & Posner 2009).

## **1.2 Gugulethu Township (Case Study)**

Over the past two decades, the HIV/AIDS epidemic has had devastating effects on the health and wellbeing of communities in South Africa. In rural areas and urban informal settlements (townships), people live with poverty, violence, abuse, poor health and unemployment (Sukati et al. 2005). In our research, we worked with people from Gugulethu Township in Cape Town, South Africa. The area has high prevalence of HIV in Western Cape province (Ministry of health South Africa 2011). Most of the HIV patients in this area access medical information by walking long distances to the clinic. Most of these patients are poor and sometimes, they cannot afford to visit the clinic regularly for medical advice. In this township, there is scarcity of Health Care

Workers (HCWs). The HCWs toil on many fronts to meet the enormous demand for the HIV/AIDS services but they are not able to meet the patients' needs.

Information and Communication Technology (ICT) solutions have shown potential in medical practice (S.S. Abu-Naser , H.El-Hissi , M. Abu-Rass 2010). The powerful functionality of available technologies such as network communication, expert systems and medical informatics allows health information to be effectively distributed to both HCWs and patients. Advance in Internet and mobile computing has also become a vital source of information technology in health care (Ganapathy et al. 2008). Mobile health (m-Health), the provision of health services enabled by mobile communications, is revolutionizing the way healthcare is delivered. From text message campaigns disseminating information on healthy lifestyles, to the use of smartphones as medical devices capable of diagnostics and remote monitoring, mobile technology has permeated every aspect of global health systems (Qiang et al. 2012). In the process, this technology will cut the costs associated with provision while maintaining and improving quality of care and reaching patients for whom access to healthcare has, until now, been limited.

We interviewed the HCWs and patients at Gugulethu clinic to acquire the system requirements before developing an advisory expert system. The system was fed with common HIV-related symptoms and the appropriate home remedies that are used to manage the symptoms. The system allows HIV-patients to request for the appropriate home remedy for the HIV/AIDS-related symptoms they are experiencing. The medical information can be accessed using mobile phone technology since most of the people in the area do not own computers. Most of them own internet enabled phones (Beger & Sinha 2012).

To carry out our research, User Centered Design (UCD) method was used. This involved the HCWs and the HIV-patients in the design and development of the system. The users were involved in the following process; requirement gathering, requirement specification, design and system evaluation. Interviews were conducted to gather the requirements of the system and also to evaluation the system. Participatory design was used during the design process. We worked closely with the HCWs and enabled them to have an equal opportunity to contribute their ideas. Low-fidelity items such as paper and pen were used to help facilitate the communication of

ideas. Paper-based mock-up interfaces and scenarios of workflow were used to assess the logical feasibility of the system design.

### **1.3 Research Motivation**

Gugulethu area has a high prevalence of HIV/AIDS. Most of the HIV-patients in this area rely on the medical provided at Gugulethu clinic. The clinic has 274 registered HIV-patients who attend the counseling session. The clinic has few HCWs and they seem not to handle the increasing number of HIV-patients. They toil in all means to offer their services to the patients but, despite their effort, they are not able to reach all patients. The patients travel long distances to go to the hospital. Sometimes, they lack funds to travel to the clinic. With insufficient medical information, the patients struggle with the disease thus the increase in HIV-related deaths.

With this research, we aimed at examining how advisory expert system can be used to disseminate nutritional and psychological support advice to People Living with HIV/AIDS (PLWHA). We focused mainly on how the patients can use their mobile phones to access the information. We focused on the use of this technology because most of our research participants did not own a laptop or desktop computer, and most of them admitted to be using their mobile phones to access the internet.

Through field study, we were able to understand how the HCWs deliver nutritional and psychological support information to the patients during the weekly training session. We also discovered that the clinic had previously used mindset health system to support PLWHA. The main aim of mindset health system at the clinic was to provide care, management and treatment programs of HIV/AIDS to HIV-patients. The system was also supposed to improve the health service delivered by the HCWs. Unfortunately the HCWs and the patients were not using the system. The HCWs relied on booklets provided to them by the ministry of health to deliver information to the patients.

Given wireless technology's rapid adoption and its extensive geographic reach, advisory expert system has tremendous potential to reach most HIV-patients in Gugulethu. The patients can access the system and use the medical information provided to self-manage the HIV-related symptom they experience.

## **1.4 Research Questions**

The primary aim of this research is to investigate whether we can create a robust web-based expert system that will provide nutritional information to PLWHA in South Africa. Most PLWHA lack up-to-date nutritional information. They travel long distance to the health care facilities to obtain this information. The advisory system we opt to create will enable PLWHA to easily access the information.

Our secondary aim is to evaluate whether the information stored in the system can be kept up-to-date. The accuracy of the information provided by the system will determine the credibility of the system.

Our final aim is to investigate whether the system is sustainable and, in the long run, improve the livelihoods of PLWHA.

In order to evaluate the feasibility of the advisory expert system as a medium of providing medical advice, three research questions were identified. These are:

**Research question 1:** Can a robust web-based expert system that provides useful information be created for PLWHA?

**Research question 2:** Can the system be kept up-to-date to ensure that PLWHA receive accurate information?

**Research question 3:** Can the system help the PLWHA to self-manage the HIV-related symptoms thus improve their quality of life?

## **1.5 Research Methodology**

Contextual inquiry methodology was used to gather requirements from HCWs and patients. Through observation, we got an insight of how the HCWs deliver the information to the patients. Interviews were conducted to get an insight of the HIV disease and the appropriate home remedies recommended to relieve the HIV-related symptoms.

User centered design (UCD) method was used in our project. To design an advisory expert system that suits the needs of the patients, we worked closely with the HCWs and allowed them to describe and interpret the system that would allow patients to access medical information at ease. It is only after we appreciated and achieved this crucial first step that we began to design the system. Iterative development was used to incorporate the changes that arose during our

interaction with the HCWs. System design went through various iterative phases of constant redesign and testing while integrating users' feedback.

Heuristic evaluation was used to identify the usability problems in the user interface design. We worked with students at University of Cape Town to evaluate the system functionality and user interface. The students went through the system to understand the general flow of the system. The design aspects that did not meet the design principles were identified and this provided a focused set of area where design needed to be improved. The system was presented to the HCWs for further testing. The HCWs were trained how to use the system. After successful training, the HCWs trained the HIV-patients how to use the system using their mobile phones. Interviews were conducted with the HCWs and HIV-patients to ensure that they were satisfied with the performance of the system.

## **1.6 Dissertation Outline**

**Chapter 2:** The literature which formulates our research on expert systems is reviewed in this chapter. The impact, prevalence and effect of HIV/AIDS in South Africa are also explained here. The importance of Information and Communication Technologies (ICTs) in developing world will be listed. We will list some of the m-Health systems that have been used in developing world. We will elaborate how they are being used to help HCWs and patients in improving health care. Lastly, we explain the use of expert system and other artificial intelligence system in health.

**Chapter 3:** In this chapter, we present the various research methods that were used to gather information from the healthcare workers and patients. These methods are used to understand users' needs and how they could be incorporated into the system to make the system more user-friendly.

**Chapter 4:** In this chapter, we describe the system design and implementation. The conceptual map of the system is presented. The use case diagrams are demonstrated. The system was designed iteratively. In the first iteration, paper prototyping was used to mimic the system. The prototypes were presented to the HCWs to show the workflow of the system. The feedback we got from the HCWs helped us to improve the design. In the second iteration, system functionalities were built. The languages used to develop the system are discussed. The system

back-end development is discussed. The system was tested and some errors surfaced. The errors were fixed to ensure that the system was working perfectly.

**Chapter 5:** In this chapter, we present how heuristic evaluation was conducted as a complementary means to ascertain that our design was up to the acceptable standards. Usability tests are also discussed. We demonstrate how the final prototype was deployed and introduced to the HCWs at Gugulethu clinic for training. The training of both HCWs and patients is discussed. The results of the study are presented and analyzed.

**Chapter 6:** To conclude, the research questions that guided our research are answered. Research contributions and the system sustainability are highlighted together with possible future work.



## **Chapter 2 : Background**

In this chapter, we will review different disciplines which we draw upon in formulating our research. We start by discussing HIV/AIDS situation in South Africa, the relationship between poverty and HIV/AIDS, home-based care for HIV/AIDS patients and stigma and discrimination among HIV/AIDS patients.

Information and Communication Technology for Development (ICT4D) is then defined. The use of Information and Communication Technology (ICT) in economic development activities is addressed. We draw our literature from academic work, NGOs and written work by individuals. We define m-Health and elaborate how it has been used successfully in developing countries.

In the next section, we discuss some artificial intelligent technologies used in the field of health. We present how expert system, Bayesian networks, fuzzy logic and rule based system have been used in health. Advisory expert system is defined and some of advisory expert systems are presented.

### **2.1 HIV/AIDS in South Africa**

Human immunodeficiency virus (HIV) / Acquired immune deficiency syndrome (AIDS) is a major global health problem. It is the greatest threat to the reconstruction and development of South Africa (ASSA 2011). Statistic carried out in 2011 show that an estimate of 5.38 million people are living with HIV/AIDS (Ministry of health South Africa 2011). This is estimated to be 10.6 percent of South Africa's population (Avert 2011). Research shows that people in rural South Africa and urban informal settlement are at highest risk of HIV and AIDS infection (Campbell et al. 2008).

#### **2.1.1 South Africa Health Facilities**

Since 1994, the government of South Africa has tried to ensure that everyone has access to healthcare (Department of Health n.d.). Despite the effort, most South Africans cannot access the services (Prof. Johnston, S and Spurrett 2011). They mostly rely on public health services (Prof. Johnston, S and Spurrett 2011). Majority of the people are widely dispersed and are unable to

access healthcare services since they cannot afford transport costs to the health centers closest to them (Schoeman S ; et al 2010).

Public health facilities have few HCWs and poor equipment, thus inadequate care. Reasons behind this shortage include: HCWs prefer to work with private hospitals for better pay. Also, some move to other countries for favorable working conditions (Ohno-machado et al. 1994). In addition, HIV prevalence among the HCWs is high resulting to absenteeism from workplace and decrease in number of public HCWs in general due to mortality.

### **2.1.2 Poverty and HIV/AIDS in South Africa**

HIV/AIDS and poverty are empirically related (Barnett & Whiteside n.d.). HIV/AIDS leads to financial, resource and income impoverishment. HIV/AIDS exacerbates poverty through morbidity and mortality of productive adults (Barnett & Whiteside n.d.). The disease worsens the conditions of people infected, thus making it difficult for them to improve their socioeconomic conditions. On the other hand, poverty perpetuates the transmission of HIV/AIDS in two ways. Firstly, People living with HIV/AIDS (PLWHA) lack resources or facilities to prevent or treat HIV/AIDS. Secondly, poverty leads individuals to generate income through illegal activities, for example prostitution that increases risk of contracting the disease. Most communities in rural areas and informal settlements in urban areas are trapped in poverty which deprives them of basic needs. They lack funds to buy food that constitute balance-diet. Inappropriate food intake impairs the immune system of PLWHA thus prolonged opportunistic infection, adverse effect on drugs absorption and decreased physical function (Raiten et al. 2005).

### **2.1.3 Stigma and Discrimination**

HIV/AIDS-related stigma and discrimination continue to be manifested in every country and region of the world, creating major barriers to preventing further infection, alleviating impact and providing adequate care, support and treatment (Skinner & Mfecane 2004) (Skinner & Mfecane 2004). Stigmatization associated with HIV/AIDS is underpinned by six factors: lack of understanding of the illness, misconceptions about how HIV is transmitted, lack of access to treatment, irresponsible media reporting on the epidemic, the incurability of AIDS, and prejudice and fears relating to a number of socially sensitive issues including sexuality, disease and death, and drug use. Stigma and discrimination arise from fear, shame and blame (Cao et al. 2006).

HIV-related stigma and discrimination affects the well-being of PLWHA. They are denied the rights to health care, work and education among others (Skinner & Mfecane 2004). Even though the law protects PLWHA, individuals still isolate themselves to the extent that they no longer feel part of the society. This is referred to as internalized stigma (Parker, R; Aggleton, P; Attawell, K; Pulerwitz 2002).

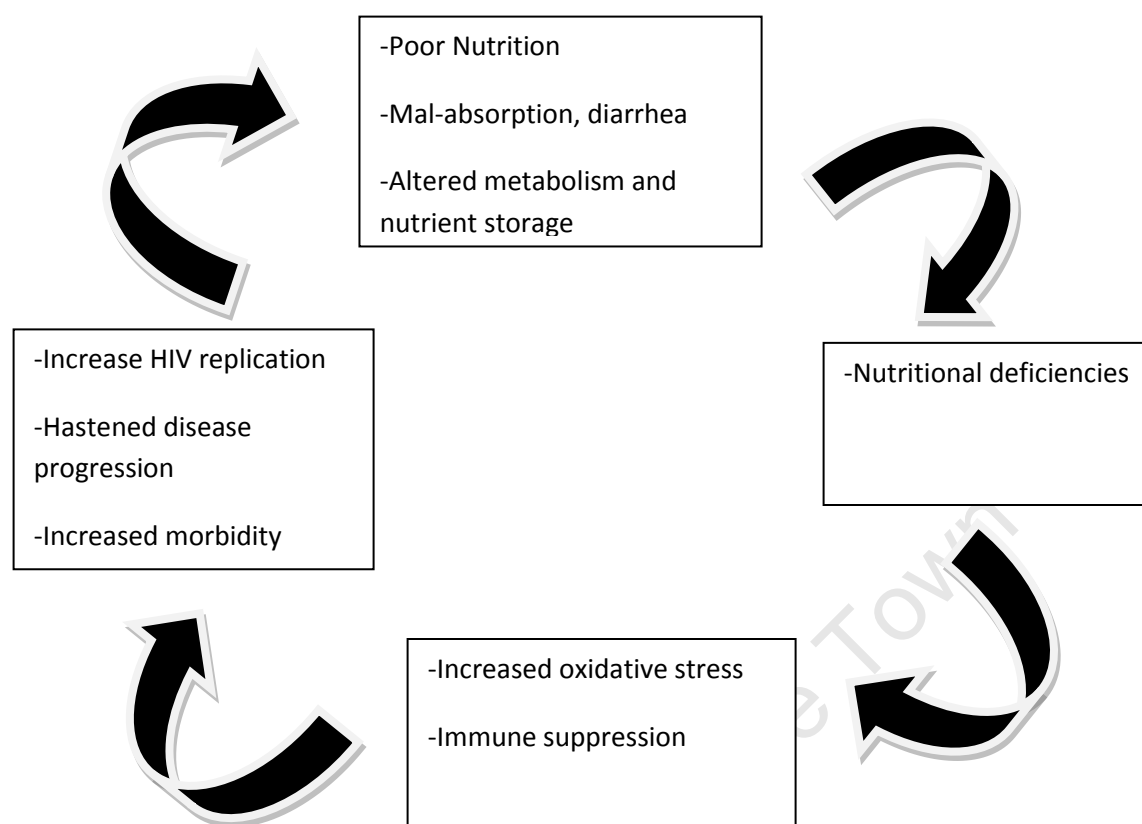
## **2.2 Home-based Community Care for HIV/AIDS Patients**

Home-Based Community care (HBC) provides complete quality health services at home and in communities. It helps to restore and maintain people's health standards and way of living by providing health care services at home. It also bridges the gap between health facilities and home care by enabling PLWHA to receive quality and dignified services in their homes, most often provided by family members (Pindani 2008). As a result of the disease pandemic, HBC services are becoming increasingly prevalent in South Africa. It has been estimated that up to 90 percent of nursing care may be provided in the home by untrained family and associates (Sørensen et al. 2008). These services do not only relieve the burden on the hospitals and community clinics, but also serve as affordable alternatives to institutional care (Malale 2011) .

### **2.2.1 Nutrition for People Living with HIV/AIDS**

The effect of HIV on nutrition begin in the early stage of the infection (Piwoz 2004). Nutritional care and support are important for PLWHA. This care should be provided from the early stage of the infection to prevent development of nutritional deficiencies (Food and Agriculture Organisation 2002). Good nutrition helps to maintain and improve the nutritional status of a person with HIV/AIDS and delay the progression from HIV to AIDS-related diseases. Good nutrition also helps PLWHA to tolerate medical treatments more easily and improve their sense of wellbeing, which in turn strengthens the immune system.

The diagram below shows the vicious cycle of HIV and malnutrition:



**Figure 2.1: The vicious cycle of malnutrition and HIV.**

Risk of death in PLWHA is high if micronutrients intake is compromised. Attention should be paid on nutrition intake even when the patient does not feel hungry. PLWHA burn-out energy at a high rate. Therefore, they need to eat more just to maintain their normal body weight. At the same time they may lose appetite or have diarrhea which leads to weight loss (Piwoz 2004). This requires constant awareness of nutrition. Most doctors recommend high-protein, low-fat, nutrient rich diets with fresh fruits, vegetables and whole grains. Small, regular meals are easier to digest than less frequent, large meals.

The relationship between HIV/AIDS livelihoods and food and nutrition is complex and multidimensional as shown in figure 2.1 above. Most of the conditions associated with HIV/AIDS affect food intake, digestion and absorption, while others influence the functions of the body (Food and Agriculture Organisation 2002). PLWHA often need to make up for protein

losses which may result from mal-absorption (the inability to take up food properly from the gut). Protein loss leads to muscle tissue breakdown. PLWHA are more concerned about their health thus leading to high stress levels. Stress affects the immune system negatively. Therefore, PLWHA need higher amount of certain nutrients during stressful periods to keep their immune system strong.

### **2.2.2 Use of Home Remedies to Manage HIV-Related Illnesses**

Literature reveals that home remedies which are readily available at home can extend and improve the quality of life for PLWHA (Szetela & Gąsiorowski 2010). Home remedies treatment involve eating healthy food, avoiding certain types of foods, psychological and emotional support and practicing hygiene to avoid skin infections (Sizani, Bandile; Nikiwe 2012). According to a report written on nutritional management of HIV/AIDS related symptoms, the specific objectives of home remedies are (Food and Nutrition technical assistance (FANTA) n.d.):

- To reduce discomfort
- To alleviate symptoms
- To ensure adequate food intake by taking locally available food

However, (Piwoz 2004) argues that, in cases where the ARV drugs stop functioning, patients can use the remedies in their households to manage the symptoms which they experience. Managing HIV/AIDS-related symptoms have the following advantages (Food and Nutrition technical assistance (FANTA) n.d.):

- Enables greater food intake by adding more flavor, encouraging consumption of small but frequent quantities of food, or presenting foods in a texture that can be easily eaten
- Increases comfort and reduces pain while eating
- Provides more nutrients to compensate for nutrient losses
- Prevents dehydration during diarrhea and fever
- Complements and strengthens medical treatment
- Reduces the severity of symptoms by providing enough nutrients

HCWs should provide information on coping with HIV/AIDS symptoms. This should be integrated in all services at health centers and in home-based care programs. During counseling

sessions, health workers and counselors should always assess how clients are managing HIV/AIDS symptoms and, when needed, help identify alternative options.

In the next section we define Information and Communication Technologies (ICTs) and how they can be used to disseminate medical/nutritional information.

### **2.3 Information and Communication Technology for Development (ICT4D)**

Information and Communication Technology for Development (ICT4D) refers to the use of Information and Communication Technology (ICT) in the developing world with an aim of bridging the 'digital divide' and aiding economic development by fostering equitable access to modern communication technologies (Tiglao & Alampay 2004). ICT refers to any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning (Tiglao & Alampay 2004). ICT is often spoken of in a particular context, such as ICT in education, health care, or libraries.

Over the past three decades, there has been a lot of discussion and debates on the role of technology in accelerating economic development in Africa (Negash, Solomon ; Patala 2006). Despite rapid worldwide diffusion of the Internet and mobile phones, a disproportionate number of users are concentrated in more developed countries thus leaving Africa behind in terms of technology. Studies show that digital divide is not only caused by inequality access of ICT, there are other issues that the poor are facing including: food insecurity, illiteracy, poor health service, gender gaps, geographical and social exclusion which hinders the adoption of ICT (Fuchs & Horak 2008). Without taking care of these factors, investment in ICT will not do much in terms of helping these people.

Despite the challenges facing the developing world, studies show that the digital divide is shrinking in terms of the numbers of fixed phone lines, mobile phone subscribers and internet users over the past decade. The International Technology Union (ITU) report in 2006 indicated that the rapid penetration of ICT in Africa is due to continuously falling price for computers, mobile phones and networks that attracted more and more people to invest in these new

technologies (Srivastava, Iara; Kelly, Tim; Lu, Chin Yung; Yu 2006). Most ICT applications are being used to facilitate communication, to easily store and process information, to automate business processes, or to widen the access to information via the World Wide Web. This broad spectrum of applications has helped ICT to diffuse in practically all sectors of the economy.

### **2.3.1 Internet Adoption and Usage**

Internet access in the developing world is seen as a major boost to the ICT4D activities (Furuholt, Bjorn; Kristiansen 2007). The Internet is generally perceived as a new engine for empowerment. The internet has become an essential tool of communication both commercially and at a personal level. The adoption and usage of Internet is changing business processes, and the way in which people live and work. In poor areas, internet access is facilitated by arrangement for public use such as internet kiosks, cybercafés or multipurpose community telecenters (Furuholt, Bjorn; Kristiansen 2007).

Over the past couple of years, there has been incredible growth, especially since the landing of undersea fibre optic cables. Also, the increase of mobile phone subscribers has increased the usage of mobile internet services (Zuckerman 2010). Most people in less privileged area do not have access to computers and they use their mobile phones to access internet services (Hsu et al. 2007). The proliferation of the internet into daily communication and activities has had its implications on almost all sectors of the economy sectors (Negash, Solomon ; Patala 2006).

The internet has met the demands of ease in access to information. By using web-based applications, more people can use the information available for economic or social purposes. In the area of medicine, the Internet-based telemedicine and medical information could be used to improve the quality of life in the rural areas in Africa.

In the next section, we discuss the impact of mobile phones in ICT4D and how the device is being used to alleviate livelihoods in less privileged regions.

### **2.3.2 Mobile Phone and their Impact in ICT4D**

Africa is said to be the fastest growing mobile phone market in the world (Rao 2011). Mobile phones have a positive and significant impact on economic growth. As telecommunication

markets mature, mobile phones in Africa are evolving from simple communication tools into service delivery platforms (Waverman et al. 2001). This has shifted the development paradigm surrounding mobile phones from one that simply reduces communication and coordination costs to one that could transform lives through innovative applications and services.

Over the past decade, the mobile phone coverage has increased in Africa (Gitau 2009). In 1999, 10 percent of Africa's population had mobile phone coverage, and by 2008, the percentage had increased to 60 percent (Aker & Mbiti n.d.). The rapid adoption of mobile phones has generated a great deal of speculation and optimism regarding its effect on economic development in Africa. Policy-makers, newspapers and mobile phone companies have all touted the poverty eradicating potential of mobile phones (Corbett 2008).

The price of acquiring and using mobile phones has radically reduced, making mobile phones more affordable (Brand South Africa 2012). With the costs of calls, data-usage and handsets falling rapidly in many African countries, there has been a continuous rise in the number of mobile phone users across the region. Additionally, the mobile phone does not require expensive investment in infrastructure as there is no need for permanent power supply and telecommunication cabling per handset; it also does not require high literacy levels as it supports a cheap form of media convergence, access and sharing hence allowing for voice communication in a flexible and mobile manner. This allows users to prefer it to other communication devices.

Mobile phones contribute to reducing poverty and improving livelihoods by expanding and strengthening social networks; increasing people's ability to deal with emergencies; cutting down travel costs; maximizing the outcomes of necessary journeys; increasing temporal accessibility; and amplifying efficiency of activities (Waverman et al. 2001).

Mobile phones have brought new possibilities to Africa. Over the past decade, there has been a number of services being offered through mobile phones (Gitau 2009). There is an emerging trend of development of mobile phone-based services (M-services) and products that go beyond basic voice calls and text messaging. These services are providing opportunities for disseminating agricultural price information, monitoring health care and transferring money in developing countries.



In the next section, we define m-Health and how m-Health services have been used to improve the provision of healthcare services.

## **2.4 m-Health**

M-Health can be defined as the emerging mobile communications and network technologies for healthcare systems (Istepanian et al. 2004). Mobile phones are being used in numerous ways in accessing healthcare services and information. The activities range from simply being able to call for an ambulance or order a medicine prescription from nearby hospitals, to more technical ones that allow doctors to diagnose patients in remote areas through mobile based applications. Health care workers and patients are using ICT to self-manage diseases, disease prevention, and continuous care management.

Studies show that m-Health has a positive effect on health care delivery in developing countries and, ultimately, it can reduce the global burden of diseases (Broens et al. 2007). It is mainly used for the following purposes:

- To extend geographic access of care
- Diagnosis and treatment
- Data collection and surveillance of diseases
- Management of health care institutions
- Access of medical information and education

Mobile phone technology can be used in any geographical area in which wireless networks provide coverage. Additionally, across the world (in both developing and developed countries), people are gaining access to the Internet via mobile phones. Given the rapid adoption and extensive geographic reach of wireless technology, m-Health has tremendous potential to scale and provide dramatically improved health outcomes. These improvements take place on two levels: first, the efficiency of health care provision is significantly improved, and second, the health services provided are more effective.

However, the ability of developing countries to overcome these serious health challenges is hindered by several core obstacles, among them a global shortage of healthcare workers. According to the World Health Organization (WHO), among 57 countries, mostly in the

developing world, there is a critical shortfall in healthcare workers, representing a total deficit of 2.4 million healthcare workers worldwide (Naicker et al. 2009). This human resources constraint intensifies the already increasing pressure on health systems in the developing world. Not only must they cope with the burden of containing the spread of communicable diseases associated with extreme poverty, they must also contend with the growing incidences of chronic diseases, such as diabetes and heart disease, an effect of newfound (relative) affluence. Governments, businesses, NGOs, foundations, and multilateral organizations all recognize the importance of leveraging new ICT tools and solutions to address these distinct but interrelated health challenges.

Despite the promise of m-Health tool for development, there are many issues that hamper the provision of m-Health systems in the context of developing world. For example, resource constraints typically mean that installation of computer components, power backups and broadband connection can be problematic, and providing training to health providers using devices can be expensive. Moreover, the absence of reliable computing infrastructure in many rural areas further compounds issues especially as more and more health workers begin to use m-Health for health care provision.

However, for M-Health systems to move to a greater level of effectiveness their sustainability needs to be ensured and their health impacts measured. There are four key factors that need to be put into consideration for the successful scale of m-Health programs. These are:

- Creating the right “fit” between m-Health applications and health care needs. The technology solution must be designed with a user-centered approach in mind, and one that keeps the health care objectives and environment firmly in sight.
- Using the simplest proven technology and implementation.
- Building upon growing intersection of e-Health and m-Health.
- Providing guidance and tools to ensure proper impact and success assessment

In the next section we will discuss some m-health systems that have been used in developing countries.

### **2.4.1 Cell Preven**

Cell-PREVEN is an interactive-computer system using cell phones and the Internet for real-time collection and transmission of adverse events related with metronidazole administration as presumptive treatment for vaginosis among female sex workers (FSWs) in Peru (Curioso 2003). The main aim of the project was to lower the rate of sexually transmitted diseases.

In the past, the HCWs would use a paper-based system to record adverse event and this information could take weeks or months to reach the doctors. The process was cumbersome and that is why they implemented the system to collect data from an existing national-urban community. An interactive voice response application for cell phones was developed. The system consists of a central database and a web server, remote access to the database from any internet connected computer, telephone audio computer-assisted personal interviewing, voice messages and Short Message Services (SMS) based communications to and from the server via the cell phone. The HCWs had an account number and credentials to log into the account. By calling using the mobile phone, they could access the system and report adverse events from the FSW. Authorized users on the other end would enter digital information about participants FSW and attach additional information in voice files. The system stores data in an online database and generates text message to mobile devices, alerting the FSW on the unusual patterns of selected symptoms.

This project demonstrated that it is feasible to develop a public health surveillance system based on cell phone, at a very low cost with no need for expensive computers.

### **2.4.2 Dokoza System**

Dokoza is an SMS-based mobile system designed to fast track and improve critical services to HIV/AIDS and tuberculosis (TB) patients (Mishra, Saroj ; Singh 2008). The system involves the use of a Subscriber Identity Module (SIM) card that can be used across networks, which interacts with existing hospital information systems. The back-end system of Dokoza is extensively rule-based for intelligent interaction to build capacity for health care worker with little knowledge. The system back-end can be accessed in real-time by using computers, smart phones and it is able to interact with fax and email. The system is well secured and it does not display sensitive HIV information on the web.

Dokoza offered the South African Department of Health a cost effective accessible national platform, with the capacity to collect and disseminate real-time data and transaction information for all patients receiving ART and TB treatments. The system is able to process an ART and TB programme in the context of particular disease management protocols managed by a chosen group of patient management clinicians. The patient clinician management is not the treating healthcare practitioner, but rather the person responsible for the design and monitoring of treatment protocols.

### **2.4.3 Intelligent Dispensing of Antiretroviral treatment (iDART)**

iDART is an ARV dispensing application. The system was developed by cell-life in Desmond Tutu HIV Foundation (DTHF) (Mukudu, A; Wright 2006). It is an open-source system. It has two components; a pharmacy application and a clinical application. The pharmacy application allows a pharmacist to dispense drugs while the clinical application allows any authorized personnel at a remote clinic to distribute the drugs.

iDart was originally implemented as a prototype in 2002. With time, a cell phone based iDart clinical application was developed. The aim of the cellphone based system was to provide a low cost simple solution for drug package tracking at remote areas in South Africa (Mukudu 2007). The cellphone clinic application is divided into two functional parts, the reading of an image and the communication of the mobile device with a server. A two dimensional barcode is used as a means of delivering shipping information in machine readable phone. The second part of the cellphone application involves communicating between the cellphone and the pharmacy server. This application was developed to automate data collection. The clinic staff would use it to collect basic data from patients. The data is uploaded to a central server in real time through mobile phone.

In the next section we define expert system. We also discuss how the systems have been developed using different technologies to provide health care services.

## **2.5 Expert System**

Expert system is a branch of artificial intelligence that makes extensive use of specialized knowledge to solve problems at a level of human expert (Liao 2005). They simulate a human expert thinking process to make decisions in a specific domain. They are designed to achieve

known and clearly defined solutions to a well-circumscribed class problem (Liao 2005). Expert systems have been developed in a diverse range of domains including health where It performs tasks such as medical diagnosis and treatment (Uddalak 2011). Expert system development is motivated by: necessity of handling an overwhelming amount of knowledge, potential to train new experts, cost reduction sometimes provided by expert systems and the desire to capture knowledge so it is not lost as personnel change. Expert systems have an undoubted contribution to health-care development in developing countries. Different technologies have been used to develop expert system in the area of health. This includes Bayesian networks, fuzzy logic, neural networks and rule based expert systems.

### **2.5.1 Bayesian Networks**

A Bayesian network is a graphical model that encodes probabilistic relationships among variables of interest (Aikins et al. 1983). A Bayesian networks can be defined as a pair of directed acyclic graph with nodes that represent a set of variables in the network and the joint probability distribution of those variables (Correa et al. 2008). Bayesian networks have efficient algorithms that perform inference and learning. Hence, they are used to gain understanding about problem domain and to predict the consequences of intervention (Heckerman 1996). Bayesian networks are used in medicine to represent and deal with the uncertainties in clinical practices (Mccall & Herrmann 2008).

In the work carried out by (Mccall & Herrmann 2008), bayesian network was used to assist some parts of medical decision making process for prostate cancer management. The network represented prostate cancer patient data using chain-model Genetic Algorithm based on nodes orderings. The model could be used in prostate cancer management by diagnosing, treatment, decision making and pathology staging. In the research work carried out by (Langmead n.d.), two algorithms are presented that showed capability in answering generalized queries for dynamic Bayesian networks. One of the algorithms was applied in medicine and its results were found to be more accurate. The network showed potential in deciding when to terminate treatment in patients thus reducing health care cost and adverse side effects .The network could also be used to help selected patients for enrolments in clinical trials.

### **2.5.2 Fuzzy logic Expert System**

Fuzzy expert systems consist of a set of fuzzy rules comprising of fuzzy model (Seising 2006). Instead of using the true and false values (also represented as 1 and 0), fuzzy expert systems use continuum

of true value in the range from 0 to 1 to cover notions such as ‘probably true’ or ‘mostly wrong’ . Fuzzy systems have proved to be potential decision making tools in medicine (Phuong & Kreinovich 2001). In the research work carried out by (Seising 2006), it proves that fuzzy logic are powerful tools in decision making and diagnosis in medicine. They handle well the absence of sharp boundaries of set of symptoms, diagnosis and phenomena of diseases. (Lee et al. 2011), developed a fuzzy expert system for diagnosing diabetes. (Phuong & Kreinovich 2001) developed and tested a fuzzy system for diagnosing lung diseases in hospitals. The systems performed tasks such as interpretation of set of medical finding, syndrome differentiation, diagnosis of diseases, optimal selection of medical treatment and real time monitoring of patient data.

### **2.5.3 Neural Networks**

Artificial neural networks are interconnection of processing units (nodes) which emulate the functionality of real neural network structure (Buchenau & Suri 2000). In the work carried out by (Papik et al. n.d.), step followed to train a neural network using back propagation are explained. They also present different neural networks applications used in medicine. (Shanthi et al. 2009) developed an artificial neural network and trained it to predicting stroke disease. The results proved to be accurate and they can be used by physicians to plan for better medication and provide patients with early diagnosis

### **2.5.4 Rule Based Expert systems**

Rule based expert systems use rules such as if-then to solve real world problems that would require human intelligence (Buchanan, B.G; Duda n.d.). In medicine, the rule based systems are used for diagnosis.

Knowledge is acquired from experts and stored in the computer as rules. The inference engine seeks information from the knowledge base and provides solution the way a human being would.

In the work carried out by (Prasad et al. 1996), a rule based expert system is used in diagnosis and therapy of lung transplant. The system returned results which suggested accurate diagnosis and therapy. For seven years in rural India, computer based diagnosis systems are in use to mitigate the problem of lack of physicians (Friedman 2009). In the work carried out by (Ndié & Tangha 2010) an expert system called MEDIAG (Medical Diagnosis) was developed that allows the patients to access medical services before they meet the doctors. In the study carried out by (Karabatak & Ince 2009), they present an idea of an automated expert system used to diagnose breast cancer.

## **2.6 Advisory Expert System**

Advisory systems may be described as the programmes whose main target is to simulate human expertise in the specified narrow branch of knowledge (Gustafson et al. 1994). Advisory expert systems in health have a role of enhancing the consistency of care (Shanthi et al. 2009). They have potential to provide advice to patient in the same manner in which a clinical expert would provide the advice. They can be used where there is scarcity of clinical experts. With a suitable user interface, the patient can access the information being disseminated.

Several expert systems have been developed to combat HIV/AIDS pandemic. Customized treatment strategy for HIV (CTSHIV) is a rule-based expert system that was developed to recommend an individualized treatment for HIV patients (Pazzani & Tilles n.d.). CTSHIV provides the HIV patients with a treatment strategy that avoids the antiretroviral agents for which a resistance has developed.

CTSHIV was implemented using JAVA. It contains a knowledge base that encodes information from the medical literature on drugs resistant mutation. It also contains rules that rank and weight. CTSHIV uses its knowledgebase to find the level of resistance of each drug and can find the weighting of each combination of drugs.

E-Medical Diagnosis Expert System (EMDES) is an interactive expert system used to diagnose the HIV disease (Vijayalakshmi, K; Sreedevi & Kumar Naveen, R and Padmavathamma 2011). EMDES uses RMPJ<sub>2</sub>RSA cryptosystem and signature schemes to ensure secure communication among the users. For the system to perform diagnosis, the patient is required to login securely to

the EMDES server and register personal data. The patient's symptoms are accepted by the inference engine of the system as user input queries and a response to the question is sent to the patient. To arrive to the appropriate diagnosis, the system performs CD4 lymphocyte count test. The knowledge base is used to derive about the situation presented by the patient. The HIV therapy system evaluates the clinical data to confirm whether the patient is infected with the HIV or not. If confirmed, the HIV Therapy system identifies whether the patient is in early stage, intermediate Stage or advanced stage.

In January 2005, the department of computer science, University of Botswana received funds from Microsoft, USA to run a project termed as Integrated Healthcare Information System through Mobile Telephone (IHISM). The aim of the project was to explore the use of mobile phones as an access technology to provide the general public with information related to HIV and AIDS (Masizana-Katongo, A.N; Leburu-Dingalo, T.K; Mpoeleng 2009). An online expert system was developed to provide general information about HIV and AIDS. The system would be queried by users using mobile phone technology. The system accepts Frequently Asked Questions (FAQ) as inputs from the users and provides the appropriate answer to the question posed. Accuracy was an essential aspect in the project. HIV and AIDS information had to be accurate. The system was developed using Exsys CORVID development tool (Masizana-Katongo, A.N; Leburu-Dingalo, T.K; Mpoeleng 2009). It consists of a user interface, inference engine and knowledge base. The user interacts with the interface which consists of a graphical screen. A question is typed on the screen and a response is displayed from the system. The inference engine uses the problem-solving logic to emulate the decision-making of a domain expert. The knowledge base is built from mainly from the FAQs and answers manual of a local HIV/AIDS information call center, Ipoletse (Masizana-Katongo, A.N; Leburu-Dingalo, T.K; Mpoeleng 2009). The system was found to be a good system to disseminate HIV/AIDS information. More than 90 percent of the participants found it easy to use the system. They found the system useful in their own HIV/AIDS health care support. However the knowledge base showed some uncertainties. There was a possibility that the knowledge base could not provide the expected response to the users in some cases. This presented a potential research area which includes designing a more formal or algorithmic keyword extraction methods for the questions.



## **2.7 Summary**

The HIV pandemic in South Africa together with poverty results in poor health care for PLWHA. The disease has also brought the issue of stigma and discrimination towards PLWHA. This has created a major barrier to preventing further infections. However, HBC was introduced to provide quality care to PLWHA at home. PLWHA are trained on nutrition and the home remedies they can use to manage the disease. This helps in restoring and maintaining the health standard of PLWHA. The advance in ICT has shown potential in disseminating such information to PLWHA.

With advances in ICT technologies, human expert reasoning and knowledge can be modeled and implemented in a computer program (Coombs & Alty 1984). Different methods have been used to develop these systems, namely; neural networks, Bayesian networks, fuzzy logic expert systems and rule-based systems. Neural networks are trained and used to predict diseases such as strokes. The systems are accurate and they can be used to plan for better medication. Bayesian networks are mainly used in decision making processes such as when to terminate treatment, thus reducing health cost and adverse side effects. Fuzzy logic expert systems on the other hand are used mainly to interpret medical findings and in diagnosis. Lastly, rule based systems are used for diagnosis. The knowledge acquired from experts is encoded into rules which are stored in a computer. These rules are then used for diagnosis of diseases such as lungs infections.

Medical expert systems can be used to play a supportive role. So far, they have been used effectively to provide medical advice and have certainly shown a capacity for disseminating accurate medical information. Expert systems hold and maintain significant levels of information, and provide consistent answers for repetitive decisions, processes and task. Advisory expert systems have been used as elaborated in section 2.5; however, they are either standalone or Web-based systems. This puts a vast majority of Africans in general at a disadvantage, because computer literacy, accessibility, and usage are very low in this region. Recent advances in the capabilities of mobile phones and increased usage have opened up new opportunities for innovative and complex applications that can be accessed via mobile phones.

Mobile phones have been diffusing rapidly in the industrialized economies and are being applied for a large variety of purposes. As far as health care is concerned; the mobile phone has the capacity to dramatically expand access to communications and to transmit voice and data at the

precise time it is needed, which will empower health care workers to make improved diagnoses and provide citizens with access to health care where it is needed most. System such as Dokoza, Cell-Preven and iDART have been used to disseminate medical information, survey public health and also to track drug packages. With the adoption of mobile phones in the developing world, m-Health has emerged as the most viable means of providing health care.

University of Cape Town

## **Chapter 3 : Requirement Gathering and Specification**

In chapter two we indicated how ICTs have shown great potential in disseminating healthcare information. HCWs and patients are using mobile device to self-manage diseases, disease prevention and continuous care management. In our research, we opt to develop an advisory expert system. The system will disseminate nutrition information to PLWHA in the same manner that the HCWs provide it. The system poses some questions to the patients/caregiver before it provides the appropriate information. To design the expert system to provide appropriate nutrition information to PLWHA, we needed to interact with the system users to understand the process taken to provide such information. We also needed to gather vital information required in the system development.

In this chapter, we discuss in detail various research methods that were used in gathering information from the healthcare workers and patients. Contextual inquiry, data analysis and interview methods were used to collect the data. We used these methods to understand users' needs and how the advisory expert system could help patients self-manage HIV-related symptoms. These methods also helped us to understand what type of information is sent to PLWHA. Interacting with the HCWs helped us to gauge the feasibility of our study. Interviews among PLWHA helped us to learn how and when they use the nutritional information to self-manage the disease.

To carry out our research in Gugulethu clinic, we acquired ethical clearance from the University of Cape Town as well as from the clinic. This ethical clearance can be found in the appendix.

### **3.1 Information Acquired from Gugulethu Management Unit**

In Gugulethu, there is widespread poverty, and unemployment levels are extremely high. Most residents rely on health services delivered by the state. The Gugulethu clinic serves 274 adults and 50 children on Anti-Retroviral Therapy (ART). Only patients who attended the HIV clinic regularly and who lived in Gugulethu are considered for ART. Clinical, biological, adherence and social criteria had to be fulfilled in order for patients to be eligible for ART. Only patients in stages III or IV, according to the World Health Organization classification, are eligible for ART on clinical grounds. All patients are visited at home before starting ART to verify their residence, disclosure to at least one individual and to assess support structures.

Counselors at Gugulethu clinic are always available during clinic hours to assist and support individual patients having difficulties with any aspect of ART. Patients are requested to identify a ‘treatment assistant’, usually someone living in their household, who could assist them with adherence issues.

## **3.2 Contextual Inquiry with Healthcare Workers and Patients**

Contextual inquiry is a user centered design ethnographic method, used to gather data from the user (Coble et al. 1995). It helps the researcher to understand users need by observing and interviewing them in the context of their work. In our research work we used observation and in-depth interviews with users to acquire relevant information for our research work.

In the next section we discuss how we gathered data from user using observation and interviews.

### **3.2.1 Participant Observation**

Participants observation was used to gather data from users in the field. Our first meeting was with the managers at Gugulethu community clinic. The aim of the meeting was to acquire authority to conduct our research at the clinic. We presented our ethical clearance from University of Cape Town and signed a consent letter with the clinic’s management.

After this introductory meeting, we interacted with the HCWs and patients at the clinic. Through observation we got an insight of how the HCWs deliver information to the HIV-patients. There were posters on the clinic walls instructing patients how they should manage HIV-related infection. We also attended a counseling session and we had an opportunity to understand the information provided to the patients. We recorded sample questions that patients ask concerning HIV-related symptoms. Observation allowed us to study patients in their natural setting without their behavior being influenced by our presence.

We also discovered that most of the patients were between the age of 20 and 45 years. Majority of them were women. Through the discussion, patients volunteered to explain the HIV-related symptoms which they experience and how they manage them. Patients would interact in the discussion and share invaluable advice on how they self-manage the HIV-related symptoms. The discussion was recorded and later transcribed.

During the training session, we were able to observe that most of the patients owned featured-phones. They used the mobile phones mostly to call and send messages. We followed up observation with interviews and realized that the patients were using their mobile phones to access the internet. Some of the patients who did not own internet-enabled phones informed us that they were using their relatives' mobile phone to access the internet. A few of the patients owned laptops.

We also discovered that there was a mindset terminal that was installed at the clinic. The terminal was deployed in the clinic with an aim of delivering health education and promotion of critical health issues, including the HIV and AIDS pandemic. The focus of this content was initially in the area of HIV/AIDS and Tuberculosis (TB). Health content is delivered through a comprehensive multimedia educational package, which includes video, computer based multimedia and print material (Brown 2008).

Figure 3.1 below shows a Mindset Health terminal deployed at the HIV/AIDS unit in Gugulethu clinic. The system includes a plastic hardware encasing that provides protection from both theft and accidental damage. This component of the Mindset Health system is not interactive, but linear in nature. That is, all viewers experience the content in the same manner. We realized that the terminal was not being used. The health care opts to deliver health information through the counseling sessions that were being held on Monday and Saturday.



Figure 3.1: Mindset Health Terminal at Gugulethu Clinic.

After the interview, we discovered that most patients owned internet-enabled mobile phones and they were using them as a medium of accessing the internet. This is because mobile phones have the following advantages:

- Low in price
- Do not rely on physical infrastructure thus high connectivity
- Require basic literacy to access
- Provide a media for internet Access

### **3.2.2 Interviewing HCWs to Understand HIV/AIDS Disease**

To understand HIV/AIDS disease and symptoms related to the disease, we conducted interviews with the healthcare workers in different units in the HIV clinic. The interview question can be viewed in the appendix. We started off by interviewing the nurses in the nutrition and dietary unit. As frontline care providers, nurses at this unit play a critical role in HIV care and they often provide counseling and other support to PLWHA. The nurses are equipped with nutrition and HIV materials which enables them to provide effective nutrition care and support to HIV-patients. The nurses use Nutritional and HIV/AIDS training manual that is developed by the ministry of health. The purpose of the manual is to support the nurses to provide effective nutrition care and support to PLWHA.

Learning that HIV/AIDS has no cure, the nurses informed us that nutrition plays an important role to control symptoms, support the immune system, and lower the levels of HIV circulating in the blood. The role that nutrition plays varies along the disease continuum (disease progression over many years), with consideration given to the patient's age, gender, behavior, current medication, drug history, socioeconomic status, and associated health concerns.

The patients have periodic nutritional status assessments. This involves weighing and recording their weight at each visit. Body weight assessment is required to:

- Identify those whose growth patterns are outside the normal parameters, indicating either over-nutrition or under-nutrition.
- Identify individuals at risk of malnutrition with repeated measurement (screening) over time.

- Monitor effects of nutrition interventions on various anthropometric measurements.

We learnt that the nurses train the patients on nutrition from an early stage of HIV infection. In the early stage of the disease, the patients are required to increase their energy intake. This is important to prevent malnutrition and weight loss. The patients are also advised to increase their intake of proteins and roughage. Protein deficiency is closely associated with energy deficiency. Both are often deficient in PLWHA and they need much more protein than their uninfected peers. They are also advised to take plenty of clean water (8 glasses in a day).

The HIV-patients are also trained to seek prompt treatment for all opportunistic infections and other diseases, and manage symptoms with dietary practices, especially illnesses that may interfere with food intake, absorption and utilization. They are trained to avoid certain food while they are experiencing some infection (for example, they are trained not to eat fatty and greasy food while they have stomach upsets).

Patients on medicine, including ARVs, are advised to manage the drug-food interactions and diet related side-effects by preparing and following a drug-food schedule, and use dietary approaches to manage side-effect symptoms. They are always discouraged to use traditional medicine.

They are also trained to practice positive living behaviors, such as practicing safe sex, avoiding or moderating use of alcohol and cigarettes, moderating consumption of junk foods, and managing depression and stress. They are encouraged to take part in physical exercises to strengthen or build their muscles and to increase their appetite and fitness.

Through the interviews, we gathered information of the common symptoms that are related with HIV disease. The nurses allowed us to go through the nutritional and HIV/AIDS training manual. We recorded some of the vital information we acquired from the document. The table below shows some of the symptoms that PLWHA experience and the appropriate home remedies that can be used to ease the pain (Szetela & Gąsiorowski 2010) .

Symptoms	REMEDY
Fever	<ul style="list-style-type: none"> <li>• Drink plenty of fluids</li> <li>• Have plenty of rest</li> <li>• Cool down by sponging your body with a wet cloth</li> </ul>
Thirsty	<ul style="list-style-type: none"> <li>• Take a lot of fluids in the course of the day</li> </ul>
Nausea	<ul style="list-style-type: none"> <li>• Drink plenty of fluid after meal</li> <li>• Sit up when eating</li> <li>• Try not to prepare the food yourself</li> <li>• Eat dry and salty food</li> <li>• Relieve the feeling of nausea by smelling on orange or lemon peels</li> <li>• Drink lemon juice on hot water</li> <li>• Avoid fatty, greasy or sweet food</li> </ul>
Coughing/problems catching breath	<ul style="list-style-type: none"> <li>• Use nasal spray</li> <li>• Breathe in hot vapors. Take a bowl fill it with hot water and cover your head with a towel. Breathe in the vapor deeply for 10minutes. You can add eucalyptus, mint or thyme leaves</li> <li>• Take two tablespoon of honey trice a day</li> </ul>
Constipation	<ul style="list-style-type: none"> <li>• Drink fluid throughout the day</li> <li>• Exercise regularly</li> <li>• Eat small meals regularly</li> </ul>



Chills (feeling very cold)	<ul style="list-style-type: none"> <li>• Prepare and take chicken soup regularly</li> </ul>
Burning with urination Difficulty concentrating	<ul style="list-style-type: none"> <li>• Drink a lot of water during the day</li> <li>• Take cranberry juice as soon as symptoms appear</li> </ul> <p>N/B if symptoms persist more than two days seek medical attention</p>
Wheezing	<ul style="list-style-type: none"> <li>• Put your feet in hot water</li> <li>• Take 1 garlic clove, add it to honey (one teaspoon) and take two times daily.</li> <li>• Take lukewarm water throughout the day</li> <li>• Take fresh juice of lime or lemon at regular intervals throughout the day</li> <li>• Mix ½ tablespoon of turmeric powder in warm milk and drink at night. This helps to relieve wheezing</li> <li>• Put hot water in a bucket and inhale steam. This helps to clear the air passage and nasal congestion</li> <li>• Do breathing exercise for 10 to 15 minutes daily</li> <li>• Avoid cold drinks</li> <li>• Avoid flowers, pollen, pets and chemicals.</li> </ul>
Diarrhea	<ul style="list-style-type: none"> <li>• Do not stop eating, drink a lot of fluids</li> <li>• Eat soft vegetables and fruits to replace minerals</li> <li>• Eat small and frequent meals</li> <li>• Eat warm food rather than cold food</li> <li>• Avoid fatty food</li> <li>• Avoid spicy and chilly food</li> <li>• Avoid milk products</li> </ul>

Gas/bloating	<ul style="list-style-type: none"> <li>• Do not drink too much fluids with food</li> <li>• Avoid food that create gas in the stomach</li> <li>• Avoid sugar and sugary product from your meals</li> </ul>
Sore throat	<ul style="list-style-type: none"> <li>• Squeeze lemon and mix the juice with crushed ginger sieve and take a large spoon of the mixture</li> <li>• Gargle a strong solution of warm water and salt several times a day</li> </ul>
Prominent leg veins	<ul style="list-style-type: none"> <li>• Reduce the pressure in your legs and feet by propping your legs up whenever you are sitting or resting.</li> <li>• Avoid prolonged periods of standing, or sitting, especially with your legs crossed</li> <li>• Avoiding tight clothing and sitting or standing positions that can restrict blood flow in your legs.</li> <li>• Treat the prominent veins by wrapping them with soft cloths soaked in apple cider vinegar for thirty minutes.</li> <li>• Exercise regularly for ½ hour 5 times per week. Walking, swimming and dancing are great ways to develop healthy muscle tone in your legs and keep the blood circulating</li> <li>• Periodically rest with your legs elevated or lie down on your side at least for 1/2 hour twice a day.</li> </ul>
Sore/bleeding gums	<ul style="list-style-type: none"> <li>• Eat unsweetened yoghurt. Yogurt introduces beneficial bacteria in the digestive system and helps to balance bacteria in the mouth</li> <li>• Mix salt in a glass of lukewarm water. Rinse your mouth with this solution in the morning and evening.</li> </ul>

	<ul style="list-style-type: none"> <li>• Use a soft brush; and brush after every meal</li> <li>• Rub some clove oil on your gum</li> <li>• Consume food items containing low saturated fats.</li> <li>• Avoid sugar, fruit juices, white flour and soft drinks.</li> <li>• Rub a solution of baking soda and water on your gums and then brush your teeth. Baking soda neutralizes the activity of bacteria in your mouth.</li> <li>• Increase the consumption of fresh fruits and vegetables.</li> <li>• Stir one teaspoon of sea salt in one cup of clean, warm water. Swish around mouth vigorously for about thirty seconds after brushing.</li> <li>• Massage the gums daily with your fingertip for two minutes a day .This will increase circulation and healing</li> <li>• Limit sugar intake</li> </ul>
Mouth ulcers	<ul style="list-style-type: none"> <li>• Gargle basil thrice a day</li> <li>• Use mint as tea or gargle for mouth sores.</li> </ul>
Nose bleeds	<ul style="list-style-type: none"> <li>• Place an ice pack on the bridge of nose</li> <li>• Lie on the ground and have someone firmly smack the bridge of each foot with the palm of their hand.</li> <li>• Pinch the nose firmly (but not hard) at the bridge of your nose just below the bone. Hold this pinch for 2 to 3 minutes until bleeding stops.</li> <li>• Do NOT blow your nose. This will blow the clot out and make it start bleeding again.</li> <li>• Do NOT lie down or tilt the head back, as this makes the blood go down your throat</li> </ul>

**Table 3.1: Table showing the HIV-related symptoms and their remedies**

### **3.2.3 Information provided to HIV-Patients by Counselors**

Counselors provide counseling and education at the local clinics and community programs to increase awareness, personal risk perception and prevention of HIV/AIDS among men and women. At Gugulethu clinic, counselors have been employed to:

- Disseminate correct and relevant information on HIV/AIDS in the community
- Promote HIV/AIDS prevention strategies in the community
- Counsel patients on various HIV/AIDS aspects
- Provide pre and post HIV test counseling
- Provide care and encouragement to HIV/AIDS infected individuals
- Counsel and educate in the clinic and communities
- Increase “personal risk perception” among the youth, men and women by involving them to actively participate in HIV/AIDS preventive education in the community

We conducted an interview with the counselors to gather information of how they deliver information to PLWHA. We learnt that counseling sessions were held every Monday and Saturday between 10a.m and 11a.m. The counseling services offered at the clinic focus mainly on pre and post-test counseling. They gave us the documents they use to train the patients. The training session are divided into three major topics: prevention, nutrition, medical management, and psychosocial issues.

#### **3.2.3.1 Prevention Information**

In prevention, measures have been taken to stop the spread of HIV/AIDS by informing and enlightening people on how the disease is spread and how to protect themselves. Patients are informed about the existence of HIV, the means of transmission and the consequences of infections. They are advised to use condoms during every act of sexual intercourse, and move from high risk to low risk sexual activities, such as having fewer sexual partners. Pregnant women are advised on how to prevent Mother to Child Transmission (MTCT). They are also trained on how take proper diet while pregnant.

### 3.2.3.2 Nutrition Information

Nutrition interventions improve the quality and reach of care and promote successful treatment. The goal of dietary management of HIV/AIDS-related symptoms is to prevent mal-nutrition and improve the health and nutritional status of PLWHA, thereby slowing the progression of the disease. Patients are taught on the role of good nutrition in the management of HIV/AIDS. They are informed how HIV infections affect nutrition through increase in resting energy expenditure, reductions in food intake, nutrient mal-absorption and loss, and complex metabolic alterations that culminate in weight loss and wasting common in AIDS patients.

There are several nutrition and food-related interventions that counselors consider in their training. These are the HIV positive individual's lifecycle state (for example child, pregnant or lactating, other adult), degree of disease progression (for example asymptomatic, symptomatic, AIDS), and whether patients have initiated ARV therapy. The main nutrition interventions are categorized as follow:

- **Nutrition for positive living:** This includes nutrition counseling and support to improve food intake and maintain weight during asymptomatic HIV infection and to prevent food and waterborne infections.
- **Nutritional management of HIV-related illnesses:** This includes counseling to manage nutrition-related symptoms of common HIV-related infections such as loss of appetite, oral sores, and fat mal-absorption among others. Home-based care programs, community efforts, and clinical services provide counseling to help HIV positive individuals and their households to optimally use available foods to manage symptoms and maintain food intake. The counselors use materials provided to them by the ministry of health to support nutritional management of symptoms.
- **Management of ARV interactions with food and nutrition:** This includes providing information and support to help ARV clients manage side effects such as nausea and vomiting and prevent drug-food interactions. Side effects and interactions can negatively affect medication adherence and efficacy. Supporting ARV clients in appropriate dietary responses to manage these conditions helps ensure successful treatment.
- **Nutrition for HIV exposed children:** This includes counseling on feeding options for HIV exposed children, including orphans, and support for safer breastfeeding or

replacement feeding, per protocols set by the ministry of health, South Africa. Food rations, therapeutic foods, and micronutrient supplements may also be provided, depending on local circumstances such as food availability, diet quality, and malnutrition rates.

### **3.2.3.3 Psychosocial Support Information**

Psychological interventions are able to ameliorate various forms of mental health difficulties that HIV patients go through. One of the most common psychological issues linked to HIV is depression. Depression is generally characterized by intense feelings of sadness or despair; depression can also yield periods of apparent emotional apathy or burnout. Heightened levels of depression are associated with facing barriers to accessing HIV care (including distance to travel, stigma, availability of quality medical and psychological services, and personal resources). In turn, depressive symptoms are linked with people having less safe sexual behavior, and not expecting support if they disclosed their status.

Psychological interventions can make a considerable difference to the long term health and wellbeing of people living with HIV, including how well they manage their condition and adhere to treatment. In order to better address psychosocial issues in the context of HIV, the counselors started support groups to increase the level of community involvement in the treatment, care, and support of PLWHA and their families. Support groups are an appropriate way of delivering psychosocial support to people living with HIV/AIDS.

Participants benefit emotionally through receiving psychosocial support from other people, through forming new friendships, companionship, reduced isolation, networking and increased self-confidence. They also benefit through receiving information, such as up-to-date information about medication and treatment for HIV/AIDS, coping skills, women's health issues, safe sex, sleep, hygiene, communication skills, nutrition, exercise, relaxation, daily living and legal issues. Furthermore, support groups provide instrumental benefits through teaching skills and through supporting behavioral change.

### **3.2.4 Communication between Patients and the HCWs**

During the counseling session, we recorded the conversation between the patients and the HCWs. The patients asked question related to HIV-nutrition. One of the patients asked whether fizzy drinks could be included in his diet. The HCWs informed them that they should avoid fizzy drinks because they have excess chemicals that are not healthy. Patients were advised to take healthy drinks such as milk which has nutritional value. They were also advised not to include spices in their meals. They were informed that they should take a balance diet in all their meals.

Concerning stigma and discrimination, most patients said that they are affected mostly at their places of work and in the communities. The HCWs advised the patients to always maintain a positive attitude. The HCWs also provided the patients with a review of their rights in receiving services at work.

### **3.2.5 Information Acquired through Document Analysis**

To collect the relevant data for our system we conducted a document analysis on the materials the HCWS were using to train and support the HIV patients. We went through the training material and recorded the common symptoms that are associated to HIV/AIDS. We also went through the nutrition materials in the clinic to acquire the appropriate remedies used to manage HIV-related symptoms.

The HCWs gave us a book to us that has information regarding HIV-related symptoms in every stage of the disease. They also recommended some medical journals that had more data that was relevant to our system.

## **3.3 Summary**

Through a series of interviews, observations and document analysis, we discovered that nutritional and psychological support information is disseminated through their counseling session and through the social groups that are facilitated by counselors. Based on the report gathered through these methods, information reaches only those patients who avail themselves to the clinic and social groups in the community. We also discovered that patients are advised to use home remedies that are readily available in their households to manage the HIV-related

symptoms/infection which they experience. The patients are discouraged from using herbal medicine as this treatment is associated with reduced ARV adherence.

The counselors try their best to meet the enormous demand for the HIV/AIDS services. Despite their effort, they are not able to meet all the patients' needs. The number of people being handled by the clinic is high. Furthermore, some patients never attend the sessions and some patients need special care from their homes. Hence, the counselors need to visit them frequently to ensure they are well.

We also discovered that most of the patients in the clinic owned internet-enabled mobile phones. Most of them admitted that they first accessed the internet via the mobile phone. Those who did not own internet-enabled phone confirmed that they use their relatives' mobile phone to access the internet. A few of them owned laptops and desktop computers.

We discovered that web-based advisory system was a feasible tool to disseminate nutritional and psychological support to the HIV patients in the Gugulethu community. Advantages of a web-based system are:

- Information can be accessed on real time
- Changes can be made to the information in the system
- No more backups since information is saved in the centralized server
- Users' data can be collected easily from the database

The system will emulate the duties of the HCWs. It will be feed with information that patients can query. Our intensity to develop the system was endorsed by the healthcare worker since it was going to assist them with their duties.

In the next chapter we discuss the design and implementation of the system.



## **Chapter 4 : System Design and Development**

The Design Chapter explains in greater detail the steps initially taken to design the advisory expert system. After interacting with the healthcare workers and patients at the clinic, we had an understanding of the how the HCWs carry out their tasks. Understanding these concepts allowed us to build a conceptual model that matched the HCWs tasks. The conceptual map helped us to shape the manner in which the system captures and portrays knowledge base contents(Yoon 2009). We conducted interviews with the HCWs since we wanted to use both the iterative design model and user-centered design. User centered design allowed us to continually consult the HCWs when making design decisions throughout the development process. Our goal with user-centered design was to effectively make the system user friendly and easy to use.

In the system implementation session, the programming languages used to develop the system are presented. We also present how we designed the system database. The four database tables are listed and the relationship between the tables is explained.

After system implementation, we present the final web interface and list the steps followed to accomplish the system tasks. We had to ensure that the interfaces meet users' expectations, usability goals, and that they provide useful content.

The final design represented a simple system that incorporates all the users' requirements and specifications

### **4.1 System Design**

During our design phase, we used the HCWs conceptual model to arrange the task of the advisory expert system. We listed all activities carried out to query the system and how the system would provide the appropriate remedies. We also created a list of activities that the HCWs would follow to add/edit/delete the symptoms and remedies in/from the system. We used activity modelling which is a tool intended to capture and succinctly represent information regarding activities that are most relevant to interaction design.

#### **4.1.1 Activity Modelling**

Activity modelling is about creating a diagram that represents the dynamic aspects of a system by showing the flow of control from one action to another. We first identified a set of activities

and functionalities that would allow the system to provide the appropriate advice. We later listed the procedures carried out to query the system for accurate advice.

#### **4.1.2 Advisory System Activity List**

We developed an activity list. The first list consists of the basic tasks that needed to be carried out to feed the knowledge base of the system with the information acquired from the healthcare workers and the medical journal, and the task carried out to query the system. In response, the system provides the appropriate advice for the specific symptom that the user would be experiencing.

- Add a new symptom and its appropriate remedies in the knowledge base
  - ✓ Log in as an administrator
  - ✓ Add symptom
  - ✓ Add the appropriate remedies for the new symptom.
- Edit existing symptom and its remedies
  - ✓ Log in as an administrator
  - ✓ Click on the symptom
  - ✓ Edit the symptom
  - ✓ Click on the symptom's remedy
  - ✓ Edit the remedies
- Delete symptom and its remedies
  - ✓ Log in as an administrator
  - ✓ Click on the symptom
  - ✓ Delete the symptom
  - ✓ Click on the symptom's remedy
  - ✓ Delete the remedies

- Querying the system
  - ✓ Enter this URL: <http://176.58.116.203:8080/ehas/index.html>
  - ✓ Accept terms and conditions of the system
  - ✓ Fill in the personal information
  - ✓ Select the symptom you are experiencing
  - ✓ The system responds by providing the accurate and appropriate advice

These task lists were adopted as the basic functional requirements of the advisory expert system. They defined the specific task that the system was going to carry out.

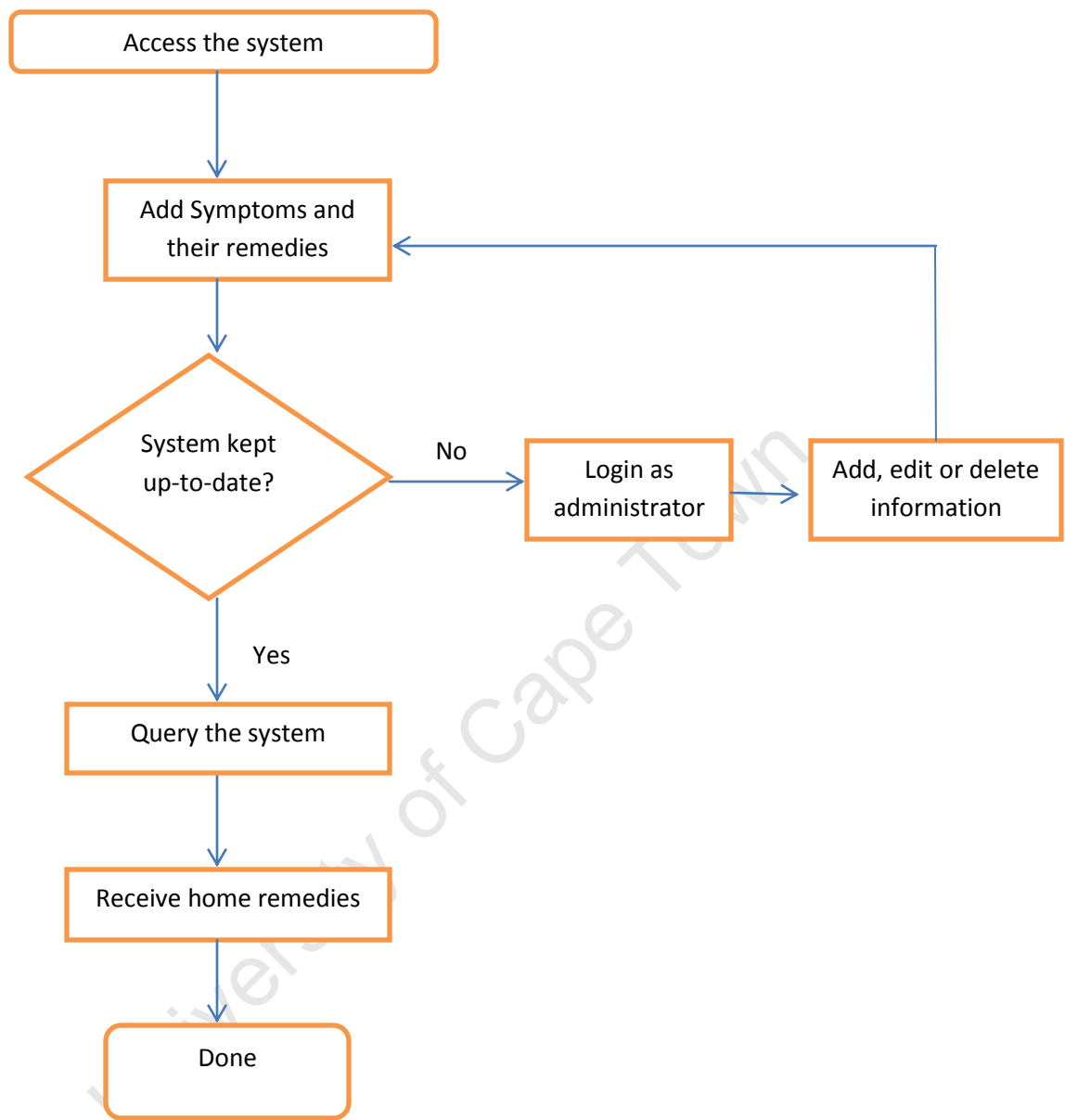
### **4.1.3 Advisory Expert System Process Flow Charts**

#### **a) Back-End**

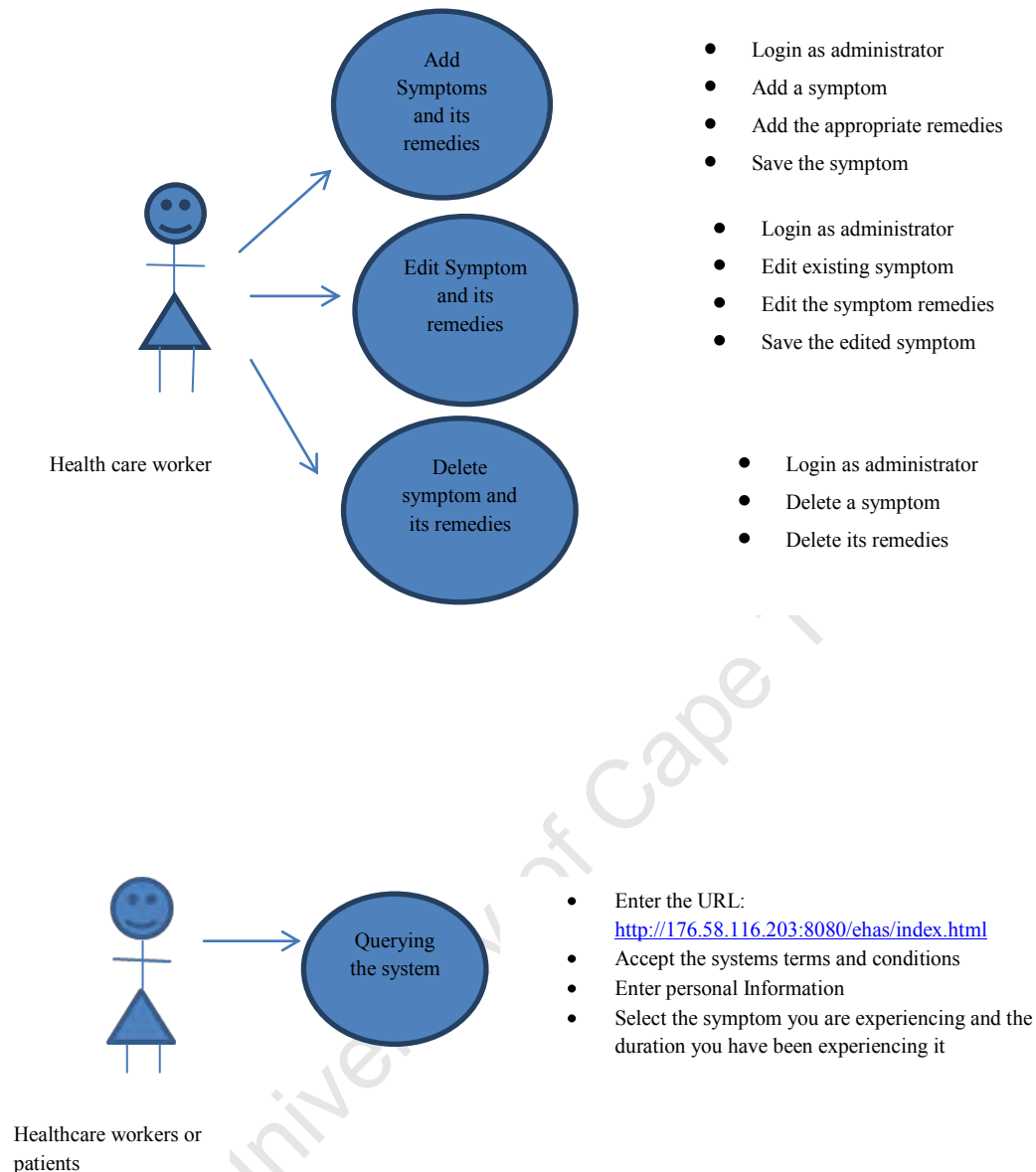
After developing a list of activities, we drew an activity flow chart of the system. The diagram shows the action taken by the user to keep the system up-to-date and also to query the system. Figure 4.1 below shows the process flow of the advisory expert system. This represents the back-end of the system.

#### **b) Front-end**

Figure 4.1 shows that the system has three major functions which were to be carried out by the HCWs who had access to the back end of the system. These tasks are: adding, editing and deleting symptoms and their remedies from the system's knowledge base. The other task that will be carried by either HCWs or the patients involves querying the system to access the home remedies. The use case diagrams below illustrate the final conceptual design for the system.



**Figure 4.1: Process flow of the system**



**Figure 4.2: Use case diagrams**

## 4.2 First Iteration

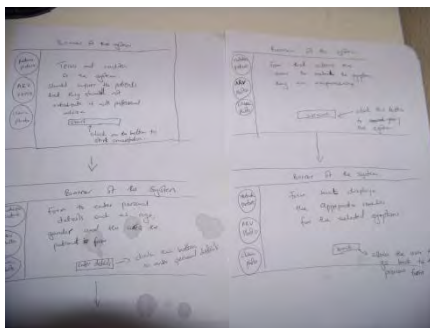
The first iteration involved developing a rapid prototype which allowed certain features to be tested by the HCWs. We involved the system users in the early stages of the design. This involved coming up with a simple user interface prototypes that would allow the patients to

access the system at ease. We refined the interfaces to fix the problems presented by the HCWs until the issues were reduced to an acceptable level.

### 4.2.1 Prototyping

To start our design process, we developed a number of prototypes to explore the usability of the system. Prototyping act as a tool for engaging with and thinking through the design problems. According to (Soegaard 2012), prototyping can either be horizontal or vertical. Horizontal prototype covers a broad range of intended future work but covers little of the actual functionalities of the system. On the other hand, vertical prototype has few features but the system functionalities are covered in depth. In our design, we used vertical prototype.

We developed low-fidelity prototypes using pencil and paper. The prototypes helped us to understand and visualize design ideas at very early stages of the design process. The prototype also helped us to understand the flow of system's tasks. We sketched various features layout with different screen orientations as seen in the figure 4.3 below.

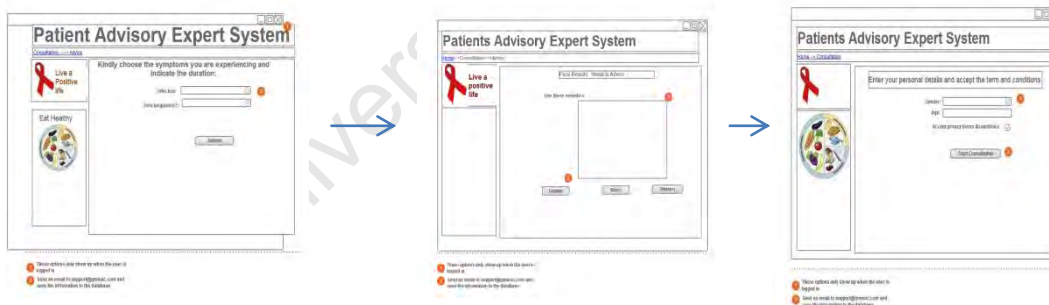


**Figure 4.3: Paper Prototype**

The prototype is a scaled-down system and represents an approximation of the characteristics of the final product. We presented the prototype to the HCWs to validate users' requirement. This paper prototype was also used to elicit corrections to the system's reasoning from HCWs and patients hence allowing us to design an interactive prototype supporting the explanations best understood by participants and the types of corrections they most requested. This interactive prototype permitted us to run offline experiments to study the effects of the corrections provided

by HCWs. Corrections were incorporated into system prototype to increase usability. Evaluation of the prototype provided useful feedback that was used in the next iteration.

Based on the feedback we got from the HCWs in our first prototype design, we improved our prototype and used gliffy, (a web-based diagram editor) to create user interface prototypes. This prototype assisted in visualizing the process involved in querying, adding, editing and deleting of information in the system. At each level of interaction, various system requirements were noted and placed in the appropriate position within the envisioned application window, this included adding of buttons, text boxes, list and views. We evaluated the prototype with the HCWs to ensure that all the functional requirements of the system were captured. The HCWs added new functionalities in the system that would help them to keep the system information up-to-date. The prototype we presented included an interface that allowed the patients to log in before accessing the information. The HCWs suggested that we remove the window. This would allow anonymity among the patients hence they would access the system freely without worrying that the system keeps their personal information. This change was adopted and incorporated in the final design. This ascertained that the system interaction modes were most comfortable and easy to use. The diagram below shows the prototypes designed using gliffy.



**Figure 4.4: Gliffy prototypes**

### **4.3 Second Iteration**

The second iteration involved creating a fully functioning system which would then be re-tested by users. This was to ensure that all the system functions were working accordingly. We first listed the system functions required to accomplish the system tasks.

#### **4.3.1 System Functions**

To develop an effective system, a list of function that would allow the user to carry out some tasks with the system was developed. From the information we had gathered from the HCWs we had to state explicitly on the home page of the application that the system is not intended to substitute professional medical advice, diagnosis and treatment offered by the healthcare workers. The users had to agree to terms and conditions of the application before proceeding with the querying process. We came up with a function that allowed the users to query the system for the appropriate home remedy to manage the HIV-related symptoms which they were experiencing. We also came up with functions that allowed the HCWs to log in the system and add/delete/edit the symptoms and remedies in the system. The list below shows the function of the system:

- Add symptom
- Edit symptom
- Delete symptom
- Add remedy
- Edit remedy
- Delete remedy
- Query the system

From the functions listed above, we developed a simple user interface that would allow the users to use the system at ease. Paying attention that most users were going to access the system using their mobile phones, we had to reduce the amount of words and use a drop down menu. This would allow the users to query the system at ease. We also had to use simple English in our system keeping in mind that most of the system users were not well educated.

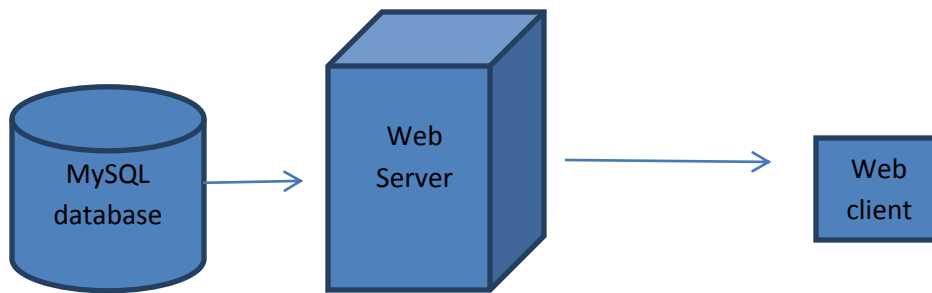


The resultant design would therefore be simple and easy to use. It will have a drop down menu, text boxes and buttons that will allow the user to navigate through the system. The system should guide the user while carrying out a task and it should be easy to interact with.

### **4.3.2 System Implementation**

#### **4.3.2.1 Programming Languages**

After developing the system's work flow and the low fidelity prototype, it was time to implement all this information into a functional prototype. We use eclipse as our development environment. JAVA Expert System Shell (JESS) was used to derive our rules. JESS is a rule-based expert system shell written entirely in Java. It uses the Rete algorithm to process the rules (Strauss 2007). Rete is a very efficient mechanism for solving the difficult many-to-many matching problem (Strauss 2007). We used JESS code since it is able to call other Java code, or be executed in a Java object. The system knowledge base was fed with the information acquired (symptoms and their remedies) from the healthcare workers and patients. JAVA programming language was used to derive the system's functions which were embedded to JESS, to query the database and return the appropriate remedies. Spring 3.0 frame-work was installed and used to create a simple work flow engine. After code completion, Maven was used to build and manage JAVA project. Maven was also used to compile the code and its packaging. The resulting design was a web-based advisory system that allowed users to query it and in response it provided nutritional and psychological advice. The system consists of few web pages that are well arranged to complete the query task. Tabs were used for easy navigation through the system. The website was hosted on a cloud server where it could be accessed by the user on the internet. The server allowed the website to access the database to retrieve and insert data on it. The diagram below shows the communication between the database, server and the client.

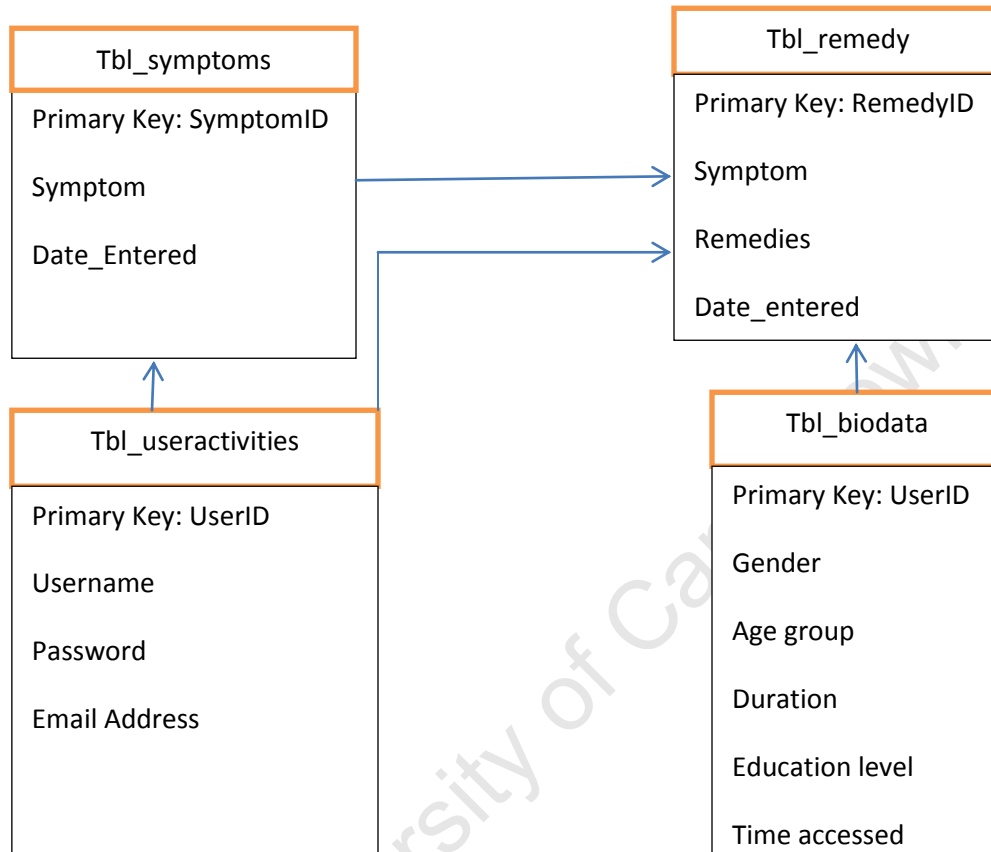


**Figure 4.5: Client Server Architecture**

#### **4.3.2.2 Database Design**

MySQL server was chosen to implement the database. We used PHPmyadmin (a graphical user interface) to easily manipulate the data in the MySQL database. MySQL and java database connectivity was used to query the database. The database was used to store all symptoms, remedies and user related information. We had acquired the database information (symptom and remedies) from the HCWs. This information was divided into two tables (i.e tbl\_symptoms and tbl\_remedies). Tbl\_symptoms stored all the symptoms acquired from the HCWs during our requirements gathering. It has a field that showed the name of the HCWs who added, edited or deleted the symptom from the table. It also has a field that shows when the symptoms were added/edited/deleted to/from the database. Tbl\_remedies stores all the remedies for each symptom. This table is related to tbl\_symptom to ensure that all the remedies correspond to the symptom stored in the database. We also developed two more tables (tbl\_usersactivities and tbl\_biodata) which stored the personal information of the system users. Tbl\_useractivities shows the HCWs who accessed the system to add/alter the information. Tbl\_biodata shows the details of the user who accessed the system. To ensure anonymity, the users did not add their name. The table only showed the user identity number, gender, age group, level of education and the time the user accessed the system. The four tables mentioned in this section can be viewed on the appendix.

In each table we specified the primary key which uniquely identifies each record in the table. We set up the table relationship to ensure that data in the table was related to other table data. Data normalization rule was applied to ensure that all tables were structured correctly.



**Figure 4.6: Database Design**

### 4.3.2.3 Web Interfaces

The screenshot below shows the web interfaces that the users were going to interact with. It shows the different tabs used to perform different tasks. Below each screenshot, there is a table explaining the steps carried out to perform each task. The first two screenshots show how the administrators add, edit, delete symptoms and remedies. The rest show the task carried out to query the system.

## a) Expert Users Interfaces

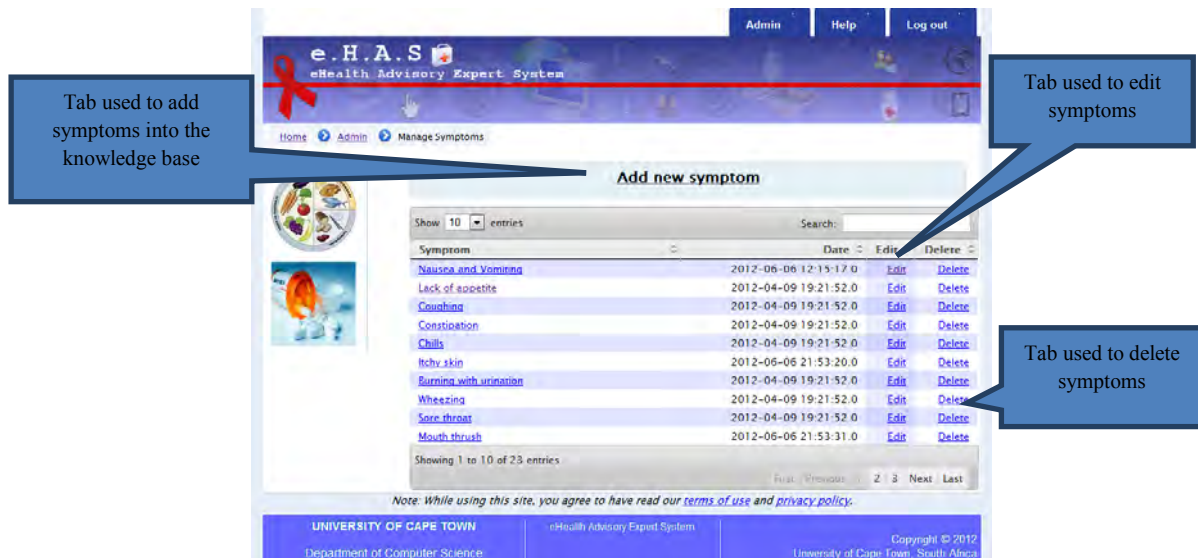


Figure 4.7: How to add, edit, delete symptoms to or from the knowledge base

Task	Steps taken
Add a symptom	<ul style="list-style-type: none"> <li>Click on manage symptoms</li> <li>Click on add new symptom</li> <li>Add an authentic symptom</li> <li>Click on save</li> </ul>
Edit a symptom	<ul style="list-style-type: none"> <li>Click on manage symptoms</li> <li>Click on edit</li> <li>Edit the symptom</li> </ul>

	<ul style="list-style-type: none"> <li>Click save</li> </ul>
Delete a symptom	<ul style="list-style-type: none"> <li>Click on manage symptoms</li> <li>Click on delete symptom</li> <li>A pop up will appear asking whether to delete the Symptom</li> <li>Click ok</li> </ul>

**Table 4.1: Steps taken to add/edit/delete symptoms from the knowledge base**



**Figure 4.8: How to add, edit, delete remedies to or from the knowledge base**

Task	Steps taken
To add a remedy	<ul style="list-style-type: none"> <li>Click on manage remedies</li> <li>Click on add new remedy</li> <li>Add the first letters of the added symptom</li> </ul>

	<p>and the system will suggest the name of the symptom</p> <ul style="list-style-type: none"> <li>• Add the appropriate remedies for the symptom</li> <li>• Click on save</li> </ul>
To edit a remedy	<ul style="list-style-type: none"> <li>• Click on manage remedies</li> <li>• Click on edit remedy</li> <li>• Edit the remedy</li> <li>• Click save</li> </ul>
To delete a remedy	<ul style="list-style-type: none"> <li>• Click on manage remedies</li> <li>• Click on delete remedy</li> <li>• A pop up will appear asking whether to delete the symptom</li> <li>• Click ok</li> </ul>

**Table 4.2: Steps taken to add, edit and delete a remedy**

## b) Patients/ Users' Interfaces

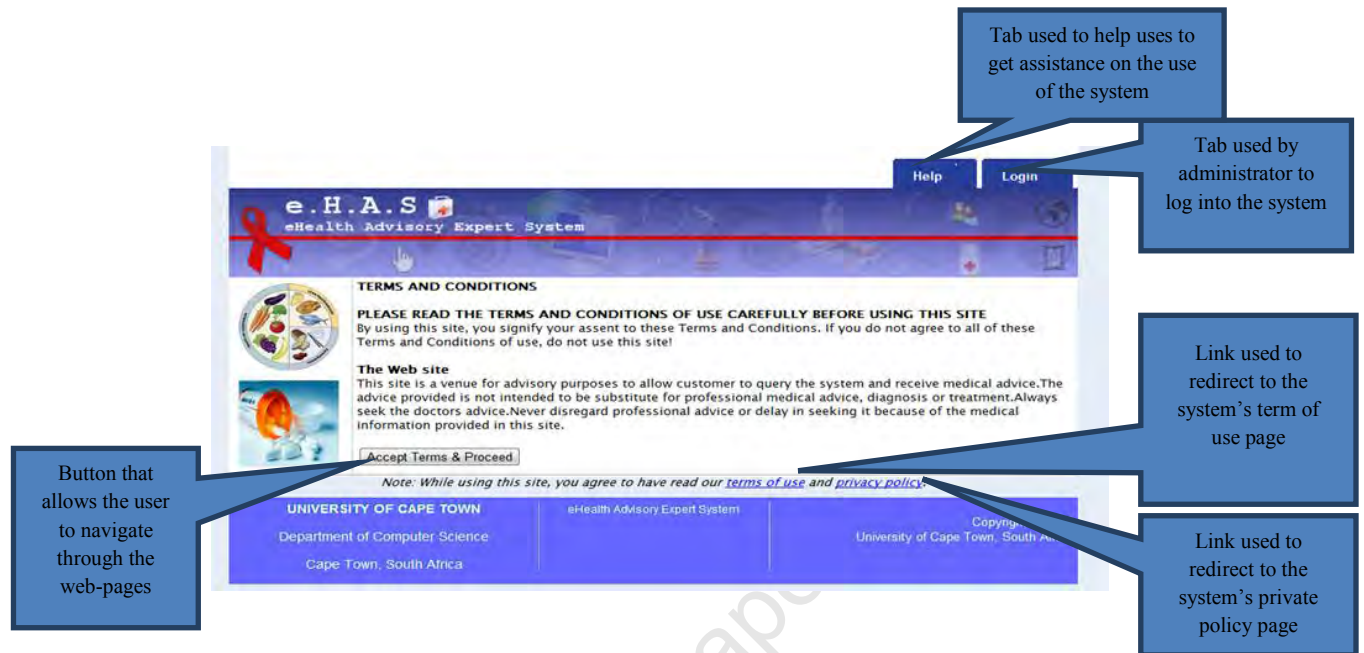
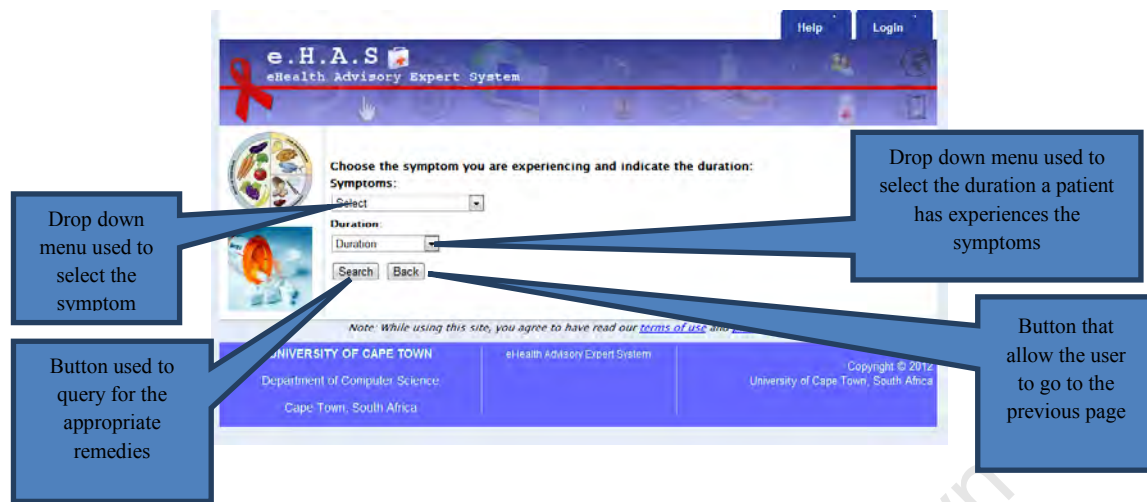


Figure 4.9: Home page of the system



Figure 4.10: Page used to enter the user's personal details



**Figure 4.11: Page used to enter the symptom and the duration of the symptom**



**Figure 4.12: Page that displays the remedies provided by the system**



Task	Steps Taken
To query the system	<ul style="list-style-type: none"> <li>• Start any web browser</li> <li>• Enter this URL <a href="http://176.58.116.203:8080/ehas/index.html">http://176.58.116.203:8080/ehas/index.html</a></li> <li>• Read and accept the system's terms and conditions</li> <li>• Enter personal details</li> <li>• Click the start consultation button</li> <li>• Select the symptom you are experiencing and the duration</li> <li>• Click on search button</li> <li>• Access the home remedies that the system provides to manage the symptoms.</li> </ul>

**Table 4.3: Steps taken to query the system**

The home page of the system consists of the terms and conditions which the user should agree to before using the system. The procedures carried out to add, edit or delete the symptoms and remedies were made to be as easy as possible since the health care workers were going to carry out those tasks. We used the radio buttons, drop down menu and buttons to allow users to query the system at ease. The back button was used to allow the user to navigate back in case they needed to change the information which they had previously entered. A disclaimer message appeared on the remedy page if the patient had experienced the symptom for more than two days. The message highlighted in red color informs the patient to visit the clinic as soon as possible. This prototype was presented to HCWs who, in this case, were the experts.

As we tested the system with the HCWs some functional error surfaced. We discovered that some system functionalities were not working. These included the log in functionality. The system presented an error whenever the HCWs logged into the system. The system could not accept their credential in the first attempt and they had to add them twice to be logged into the system. Figure 4.12 below shows the error displayed on the screen.



**Figure 4.13: Login Error**

Also, the advice provided by the system was incorrect. Some queries did not provide the appropriate advice. This called for system improvement. We had to work on the system and fix the errors. We changed the system rules to ensure that the system provided the correct advice. More rules were added to the system knowledge base. This process was intended to ultimately improve the quality and functionality of the system.

#### 4.4 Conclusion

The simplicity of the application was embraced by the HCWs. There were a number of changes required in the application. These changes were important in improving the usability and learnability of the system. Having made these changes, the system was ready to be tested in the field.

In the next chapter, we look at how we evaluated the advisory expert system for its usability and adoption into information dissemination. We also present the result acquired in this study

## **Chapter 5 : System Evaluation**

In this chapter, we demonstrate how we conducted evaluation as a complementary means to ascertain that our design was up to the acceptable standards. The system underwent heuristic evaluation with six students from University of Cape Town. The final prototype was deployed and the HCWs were involved in the evaluation of the system. We then demonstrate how the final prototype of the system was presented to the HCWs at Gugulethu clinic for evaluation. The HCWs were trained on how to use the system. The patients were trained by the HCWs on how to access the medical information. We choose to train the HCWs and HIV-patients since most of them had not interacted with computer systems before and they only had basic level of education. The evaluation specifically involved examining information accuracy, simplicity and usability of the system. The interface was examined to judge whether it complied with the recognized usability principles. After conducting the evaluation we present the system results after a period of six months.

### **5.1 Functionality Testing**

After the design and implementation process, we had our final prototype ready for evaluation. This evaluation aimed at implicitly assessing the advisory system functionality to check whether they measured up to the system's requirements. We presented the prototype to six students at the department of computer science to evaluate the functionality and the user interface of the system.

We first tested the log in function. We tried logging in with a random username and password to make sure that only registered users can gain entry to the site. This was done quite a few times and each time an error message was displayed stating that it was an invalid username and password combination. Next, we tried to add, edit and delete information to the system. We added dummy information into the system. We managed to edit the information and later deleted it. Lastly, we queried the system to ensure that it provided the correct information. The query process would not proceed if some personal information were not included. The information provided was corrected after several attempts. The system displayed a disclaimer every time we

entered symptom duration of more than three days. These functions were working perfectly as expected.

After the testing process, we were satisfied that the website was fully functional and working as expected.

## **5.2 Usability Testing**

Usability testing is an invaluable tool for evaluating the effectiveness and ease of use of a system (Gitau 2009). Usability testing was used to measure the usability goals which are: effectiveness, efficiency, learnability and memorability as the real users interact with the system. We first conducted a heuristic evaluation with the six computer science students to identify all the usability problems in the user interface design. Each student used his/her own computer to test the system. The heuristic evaluation ensured that the system was quite informative and it provided the feedback within reasonable time. The simplicity of the system ensured that the system could be used by both novice and system experts. The system incorporated simple language that allowed the users to interact with users at ease. They understood the flow of information in the system.

A test was then conducted with participants (HCWs) who interacted with the system. We used observations, scenarios, constructive-interaction and artifact walkthroughs techniques to carry out the system evaluation. Feedback on the participants' success, speed of performance and satisfaction was collected.

### **5.2.1 Heuristic Evaluation**

Heuristic evaluation is a usability engineering method for finding the usability problem in an interface design, so that they can be attended to as part of iterative design process (Nielsen 1992). We conducted a heuristic evaluation with six computer science students from University of Cape Town. Each of the students used his/her own computer to interact with the system. The evaluation was based on these heuristics:

- The system is informative: The system should inform the user of what is going on through appropriate feedback. Users should not memorize the system information. Instead, the system instruction should be visible or easily retrievable whenever appropriate.

- The system is efficient: The system can interact easily with both inexperienced and experienced users.
- The system uses understandable language: The system uses language and concepts that are familiar to the user. It should make information appear in a natural and logical order.
- User control: The system should provide the users with an option to leave or quit a process if they choose it by mistake. The system should allow undo and redo option.
- Accuracy: The result of user actions should correspond to their goals
- User support: The system interface supports learning and provides the required assistance to usage.
- Help and documentation: The system provides a help page that helps the user to walk through the system.

The evaluation resulted in a number of changes on the prototype and its usability. The following modifications were made on the design

1. **Button-renaming:** The “start” button on the index page was renamed to “Accept terms & proceed”. This alerted the users to first read the terms and conditions of the system before they start using it. If a user did not agree with the terms he/she had the liberty of not using the system.
2. **Changing the level of education on the drop-box menu:** We changed the level of education from “primary level” and “secondary level” and categorized it as “grade 1-4” “grade 5-8” and “grade 9-12”. According to UNESCO the education levels in South Africa is categorized into grades. These grades were familiar to users and they would enter the appropriate grades. This would make our work easy as we discuss the results of the research.
3. **Changing the font-size of the disclaimer:** We changed the font-size of the disclaimer from “Time New Romans 11” to “Times New Romans 14”. This was meant to make the disclaimer more visible to the users.
4. **Adding the popup message:** We added a popup message while deleting the symptoms and remedies. This was meant for the administrator to confirm whether he/she wanted to delete the information from the knowledge base.

Although the number of changes required was relatively small, these changes were important in improving the usability of the system. Having made these changes, we went back to the students and presented the system to them for further evaluation. After fixing all the errors in the system we deployed the system as it was ready to be used at Gugulethu clinic.

#### **5.2.1.1 Training the HCWs at Gugulethu Clinic**

We contacted the head of the HIV unit at Gugulethu clinic with intention of training the HCWs. We demonstrated the system to the management before training the HCWs. This was done to acquire authorization to use the system in the clinic. A training session was conducted with the HCWs. We choose to train the HCWs instead of an intuitive approach because most of them had not interacted with computer system and they only had basic education level. The training session served as a presentation of the system to the HCWs. The intention of the training was to demonstrate typical usage of the system, while carrying out the following tasks: adding /editing/deleting knowledge to/from the knowledge base and also the steps followed to query the system.

Four HCWs were appointed as the administrators of the system. A user name and unique password was given to them. This gave them the privilege to access the system knowledge base. With this privilege they could add/edit/delete the system's knowledge. The design was presented to the HCWs and we gave them a systematic walkthrough of the processes of adding, editing and deleting information to/from the system. We also gave them a walkthrough of the task required to query the system. After the training, we handed the laptop to the HCWs for them to use the system on their own. We watched them closely and helped them whenever they encountered difficulties. The HCWs were able to add, edit and delete information to/from the system. At this stage, they were conducting the task at a very low speed. They could also conduct the querying task at ease.

After several attempts, the HCWs were able to perform all the tasks. They could continue using the system without further training. They appreciated the simplicity of the system and confirmed

that the system provide the correct information. They confirmed that they could keep the system up-to-date with the information they acquire during the weekly counseling session.

After the training session, we engaged in a discussion with the HCWs. They informed us that the system was a good medium for reaching more HIV-patients in Gugulethu. They were satisfied with the accuracy of the system. They added more information to the system to ensure that the information was up-to-date. The picture below was taken after a successful training session.



**Figure 5.1: Training the HCWs to use our system**

The goal of training the HCWs was achieved. They were able to successfully add/edit/delete symptoms and remedies to/from the system's knowledge base. They were also able to perform the querying tasks. The HCWs could use the system without further training. At this stage the HCWs were ready to train the patients on how to use the system.

#### **5.2.1.2 Training the Patients**

During the weekly training session, the HCWs conducted a training session in two parts: a group training presentation and a hands-on training time using the mobile phones. During the first part of the training session, the HCWs introduced the system to the group of patients. This encouraged a sense of participation in using the system. The patients were trained on how to query the system. The system screens were projected on the whiteboard in the training room with an intention of doing a live demonstration so that all the patients could follow the querying tasks.

The HCWs used Xhosa language to explain the steps taken to query the system. We took note of the key questions that the patients were asking concerning the system. In the second part of the training session, the HCWs trained the patients how to access the system. Most of the patients in Gugulethu could only access the system by using a mobile phone.

The HCWs used the Nokia c200 mobile phone (shown in figure 5.2 below) to walk through the stages involved in querying the system. Each of the four HCWs had a phone and they engaged with the patients as they trained them on how to use the system. The patients used their mobile phones to query the system. Some of the patients did not have internet-enabled phones but they were keen to learn. They said that they were going to use their family members' phones back at home.



**Figure 5.2: Nokia C200 mobile phone**

At the end of the training, the patients were asked to raise any pressing questions involving the use of the system. Some patients complained that the phone screens were small and they could not read without their reading glasses. One of the patients suggested the HCWs print the symptoms and their remedies for them. The HCWs informed them that the system was being fed with new information every week and implementing the suggestion would imply that new printouts would be made every week. The patients were encouraged to use the system in order to access updated information.

For easy access of the system, the patients were trained how to add the system's URL on the bookmark of their mobile phones. This would allow them to click on the bookmark while accessing the system instead of entering the URL on their mobile phone browsers every time they wanted to access the system.



### **5.3 System Validation**

As our last stage of system evaluation, we validated the system against the user and system requirements. The aim was to check whether the final design was robust, accurate, simple and usable. We conducted an interview with the HCWs and some patients. Questions were prepared to guide the conversation of the interviews toward addressing the goals achieved by the system.

#### **5.3.1 Interview with the Health Care Worker**

This interview was conducted with the four HCWs who had been updating the system.

**Question: How long did it take you to learn how to use the system?**

“The system is quite simple. We learnt how to use it during the training session”, said one of the HCWs. They said that they had trained other HCWs in the clinic on how to use the system. They also said that they could use the system without further training.

The simplicity and ease of use of the system had been confirmed.

**Question: What was your experience with the system?**

The HCWs said that the system was easy to use. With the availability of internet in the clinic, they accessed the system any time. They said that they could navigate through the system and perform the entire task at ease.

**Question: How frequent did you add information to the system?**

The HCWs said that they fed the system with information after every counseling session which they held on Mondays and Saturdays. From the system log files in the appendix, it clearly showed that the information was being fed on a weekly basis. They acquired information from the nutrition counseling booklet which they acquired from the South Africa’s ministry of health. They also acquired knowledge from the discussion they had with fellow HCWs and also the patients.

**Question: Did you retrieve information from the system to provide nutritional and psychological support to the patients during your one-to-one counseling sessions?**

“Most of the time we use the nutritional manual provided to us by the ministry of health” said one of the HCWs. This is the same information that the system provided. One of the HCWs said that they retrieved the information when they had impromptu meetings with the patients during the home visits.

**Question: How accurate was the information provided by the system?**

“The information provided by the system was accurate. This is the same information we would provide to the patients if they approached us with the HIV-related symptoms which they are experiencing”. This was the response from the HCWs. They said that the information was kept up-to-date to ensure that the system provided accurate information.

**Question: Was the system a success?**

The HCWs said that the system has been a success since the patients could access the medical information from their home. “The patients can now manage the symptom which they are experiencing before they visit the clinic for further treatment.” said the HCWs.

Secondly, the HCWs said that the impromptu visits to the patients’ homes had reduced since the patients had learnt how to use the readily available remedies in their homes to manage the HIV-related symptoms.

### **5.3.2 Interviews with the Patients**

**Question: What device do you use to access the system?**

Most of the patients said that they used mobile phone to access the system because they do not own laptops or desktop computers. Those who did not own internet-enabled phones used their friends’ and relatives’ phones to access the system. Six patients said that they could access the system using their personal computer.

**Question: How was your experience with the system?**

Most patients said that the system was quite simple to understand. The steps followed to query the system were well elaborated. The system used simple language with which they could easily relate.

They only complaint was that the handset's screen was too small and they strained to access the information.

**Question: Do you find the information provided by the system credible?**

Most of the patient said that they were familiar with the response which the system was providing to them. They were confident to use the remedies provided by the system. They said that the information was accurate since it was the same information which they were being provided with during the counseling sessions.

**Question: Was the system useful?**

“The system has been of great help to me. I was having problems with my swollen feet. I accessed the system and used the remedies provided. My feet swelling reduced and I managed to walk to the clinic for further treatment,” said one of the patients. The patients agreed that the system was useful since it helped them to self-manage the HIV-symptoms which they were experiencing. They appreciated the fact that they could access the system any time and at any place.

## **5.4 Use of system in the Field**

At this stage, the system was ready to be used in the field. The patients had learnt how to access the system. The HCWs had the responsibility of helping the patients who encountered any problem in accessing the system. They also promised to help the patients at home to access the system from their relatives' and friends' mobile phone. The HCWs continued adding information into the system for a period of six months.

In the next section we present the research results acquired during the course of the experiment.

## 5.5 Results and Discussion

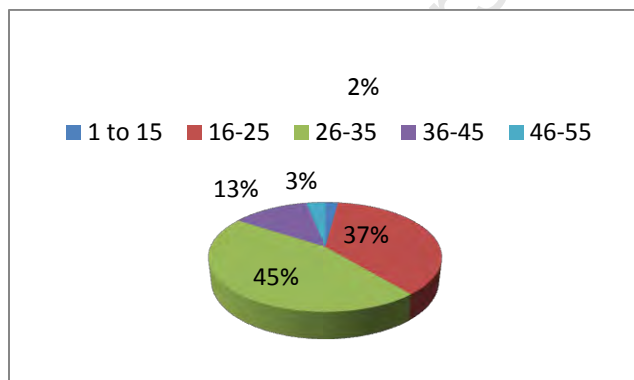
In order to answer the three research question underlying this study, statistical analyses were conducted on the data obtained during the six month period during which the patients and HCWs were using the system. This data was analyzed from the system logs. We start by analyzing the participants' demographic data which includes; age, gender and the level of education. We proceed to reporting the use of the system and how the data in the system was modified.

### 5.5.1 HIV-Patients Data

The Gugulethu clinic was attending to more than 274 HIV-patients. 150 HIV-patients were using the system to access the medical data. We acquired all the demographic data from the system log. The system ensured anonymity; we could only get the age, gender and level of education of the patients from the logs.

#### a) Age

The figure below shows that the system was mostly (45 percent) used by participants who fell in the age group of 16-25. This is because South African youths are the first adopters of mobile technology (Beger & Sinha 2012). The age group of 26-35 was also actively using the system to access medical information. The simplicity and ease of use of the system ensured that even people at the age group 46-55 could use the system to access the medical information.

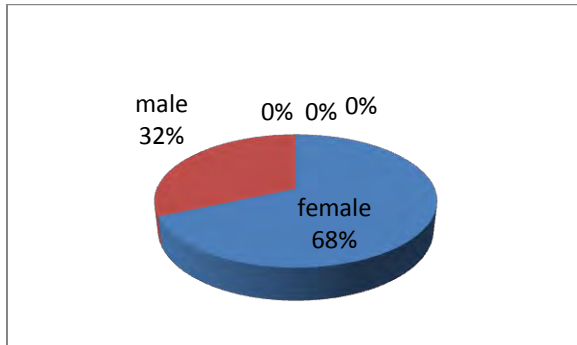


**Figure 5.3: Participants' age group.**

#### b) Gender

Majority of the participants who accessed the system were female. During the training session the women showed more interest in the system. They were most involved in asking questions

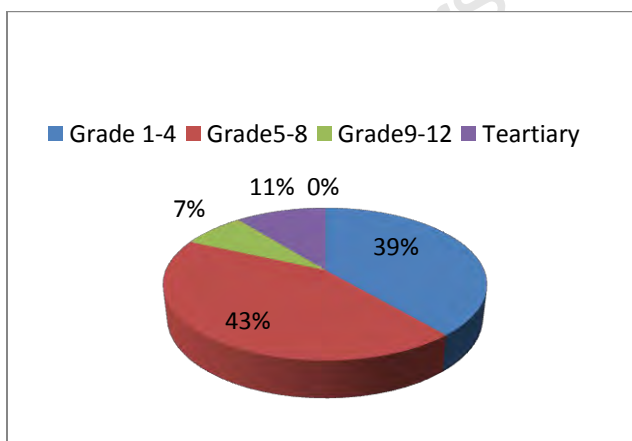
concerning the system. Most women also accessed the system so that they could use the information to help their young children whenever they experienced HIV-related symptoms. The figure below shows that 68 percent of the participants were female.



**Figure 5.4: Gender participants.**

### **c) Education Level**

Majority (43 percent) of the participants in this study had completed grade eight. 11 percent of the participants had undergone the tertiary education. From this statistic, it clearly shows that most of the people in Gugulethu have basic education level. Most of them are unemployed and rely on small businesses to provide for their families. The simplicity of the system ensured that it is easy to use and anyone can access it.



**Figure 5.5: Participants' level of education**

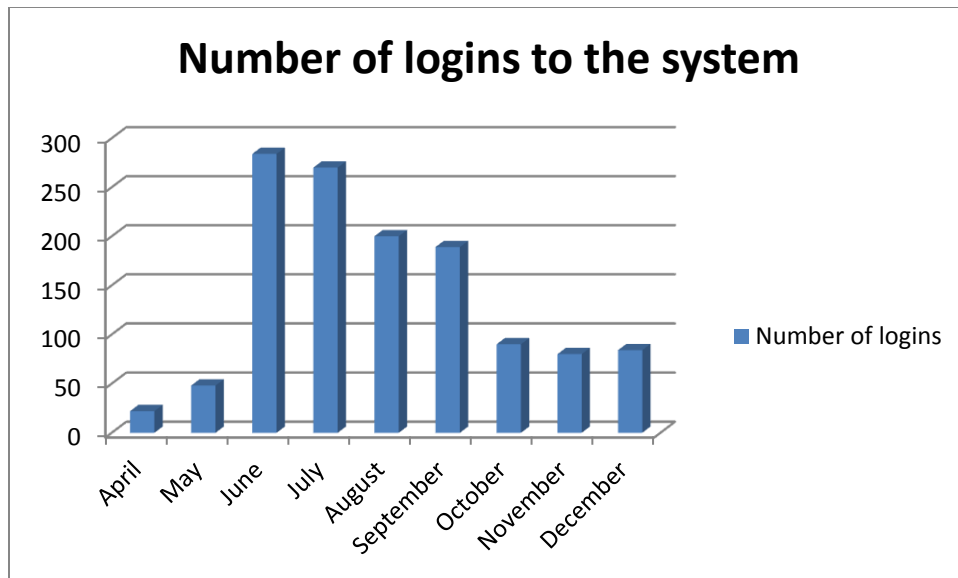
Out of 274 HIV-patients at Gugulethu clinic, 150 patients accessed the system. The results presented above prove that the system was used frequently by the patients. Most of the users had

basic education level. Young patients tend to use the system more than older patients. These results show the practicality of the system. Patients were using the system to self-manage the HIV-related symptoms which they experienced.

### **5.5.2 System Result for a Period of Six Months**

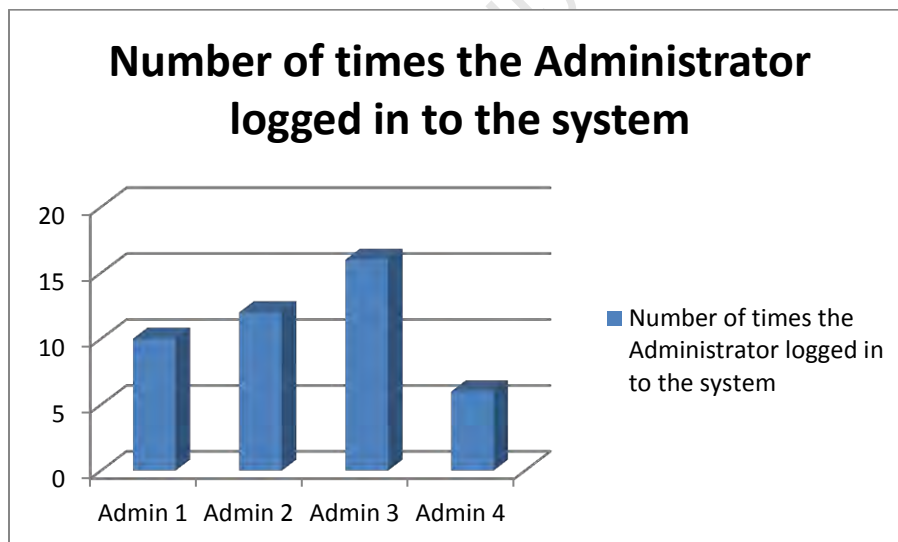
In this section we present our results on the number of users who accessed the system over a period of six months, number of times the HCWs logged in to the system to alter the information in the system and the number of home remedies added/updated/deleted in the system. These results will be represented in a bar graph. These results will try to answer the research questions we posed in chapter one.

Figure 5.6 shows the number of times the patients logged into the system. The system was up and running by end of March 2012. In April and May, few patients used the system. At this point, the HCWs were still training the patients on how to use the system. Also, at this point, there was little information in the system and the HCWs were trying to populate the system with more information. Later, the number of logins increased. The patients had fully learnt how to use the system. The figure also shows that the system was in use throughout the six months period. Most patients informed us that the system was easy to use and they had memorized the process of querying the system. This indicates the usefulness of the system

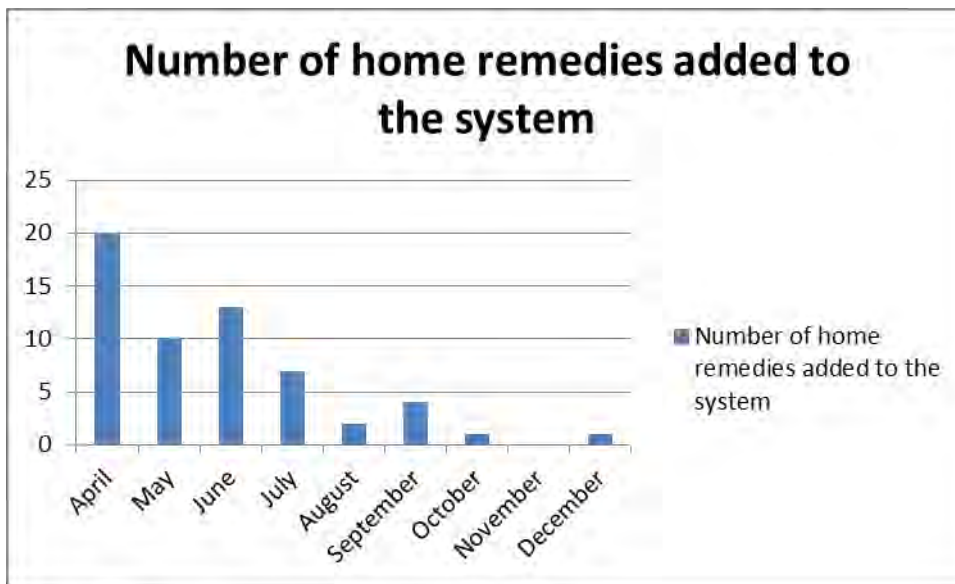


**Figure 5.6: Number of logins to the system**

Figure 5.7 shows the number of times the administrators (HCWs) logged into the system. These HCWs had been trained how to manipulate the data in the system. Their duty was to keep information up-to-date. The figure shows that the HCWs accessed and used the system at ease. The system was helping them to disseminate information to their patients and they were active in adding vital information to the system.



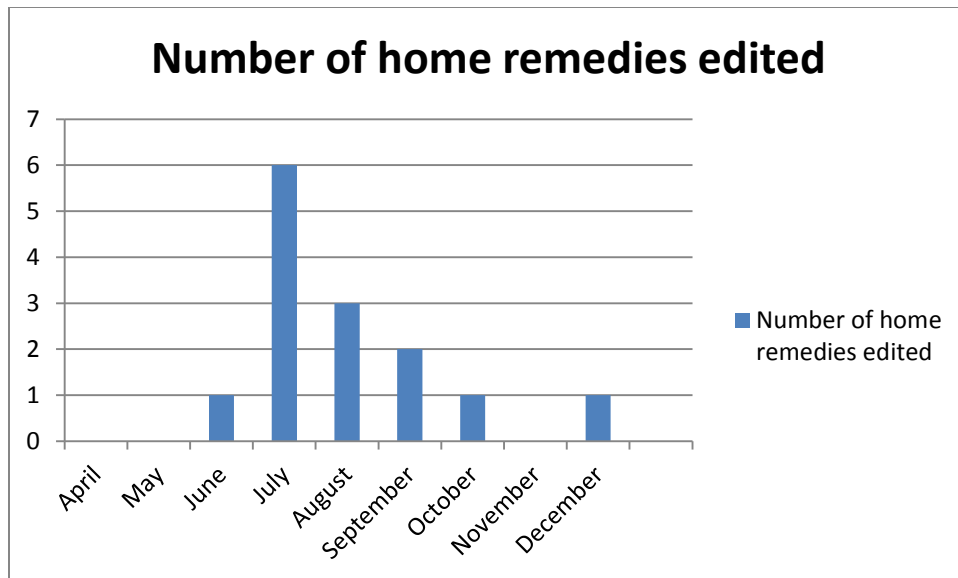
**Figure 5.7: Number of logins by the HCWs**



**Figure 5.8: Number of Home remedies added to the system**

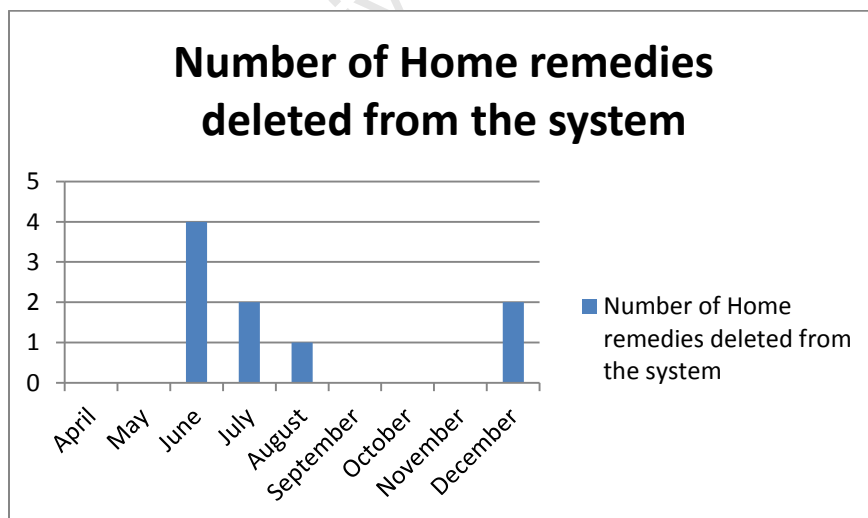
Figure 5.8 shows the number of home remedies added to the system for duration of six months. In April, the HCWs had successfully learnt how to add information to the system. At this stage the system had little information which we had added during the evaluation process. HCWs added most of the home remedies that was in their training manuals to system. For three months, the HCWs had a lot of information to feed to the system. In August, the amount of data being fed to the system started reducing. At this stage, the HCWs were only adding the information they acquired during their weekly counseling sessions. Throughout the six months, the HCWs were updating the system with new information. This proves that the system was easy to use and the HCWs had memorized how to use it. It also proves that the system was kept up-to-date to ensure that the system provided accurate information.





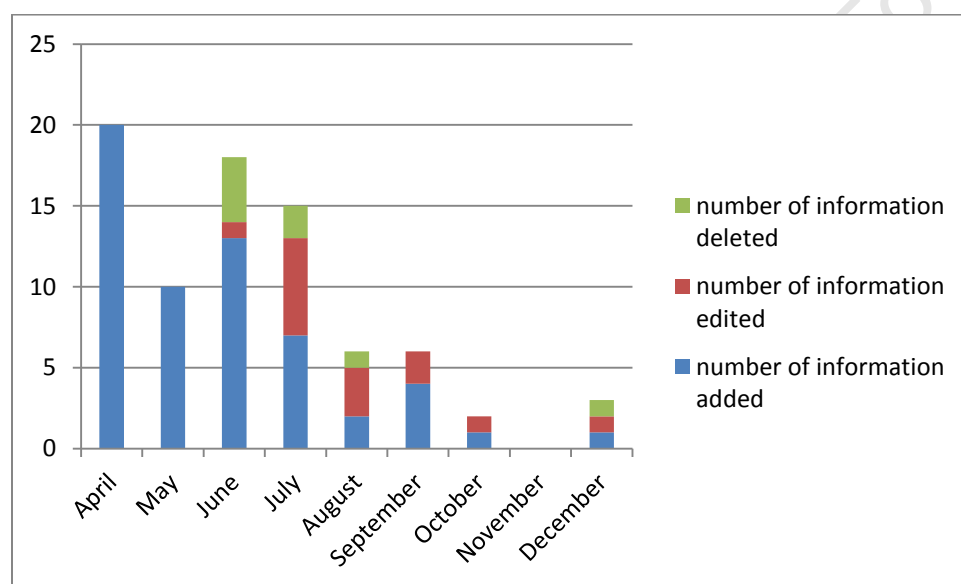
**Figure 5.9: Number of Home remedies edited**

Figure 5.9 shows the number of home remedies which were edited for a period of six months. In the month of April and May, there were no home remedies which were edited. At this stage, the HCWs were busy adding information to the system. After that, the HCWs started editing some of the information in the system. They edited the information to ensure that the patients could understand the remedies provided by the system. This ensured that the information provided by the system was accurate.



**Figure 5.10: Number of home remedies deleted from the system**

Figure 5.10 shows the number of home remedies deleted from the system. The HCWs started deleting some remedies in the month of June and July. They had to remove all the remedies that involved taking traditional medicine and spices. According to the ministry of health in South Africa, HIV-patients are not allowed to take herbal medicine since they reduce the effectiveness of ARV drugs in the management of HIV/AIDS. There are also some spices which are not supposed to be taken by HIV-patients since they cause the patients to have stomach upsets. These remedies were removed to ensure that the advice provided to the patients improves the health of the patients.



**Figure 5.11: Number of information in the system**

Figure 5.11 shows the activities taking place in six months. In April the HCWs were mostly adding information to the system. In the month of June and July the HCWs were carrying out the three tasks consecutively. At this point they had identified the benefits of the system and they wanted to ensure that the information provided by the system was accurate. This also indicates that the system was up-to-date throughout the period of six months.

Figure 5.8, 5.9, 5.10 and 5.11 show that the HCWs managed to put the system data up-to-date. This was to ensure that the information provided by the system was correct. This also indicate

the simplicity of the system. The HCWs managed to access the system throughout the six months. The system contained accurate information since the HCWs updated it frequently to ensure that relevant information was maintained in the system. This results show that the system was practical, simple, usable and efficient.

## **5.6 Conclusion**

After the evaluation process, we were certain that the system was easy to use, simple and that it provided accurate information. The HCWs and patients accessed the system for six months and proved that the system could be used to disseminate medical information. From the results acquired after the evaluation process, we proved that the system could be used by people with basic level of education. The system's information was kept up-to-date and the users found it easy to access the system. The HCWs could use the system without further training. The HIV-patients who accessed the system confirmed that the system had helped them to manage the HIV-related infections which they experienced.

## **Chapter 6 : Conclusions**

This chapter summarizes the work which has been done, and specifically, how the research questions have been answered. Our experience at Gugulethu clinic is also explained. Furthermore, we highlight our research contributions and the system sustainability. Some research possibilities for future work are then suggested.

### **6.1 Advisory Expert System**

To accomplish the aims of this project, we developed an advisory expert system. The aim of the system was to disseminate nutritional and psychological support information to PLWHA. The system was meant to be used by HIV-patients to access medical information from any geographical location. The information helped the patients to self-manage the HIV-related symptoms which they experienced. The system was fed with information by the HCWs to ensure that the information provided was accurate. Most of the patients in Gugulethu accessed the system using their mobile phones. The system helped the Gugulethu clinic to reach more patients in the area. This reduced the trips made by HCWs from home to home checking on the HIV-patients.

### **6.2 Research Questions**

In this section, we revisit the three research questions we formulated in section 1.4 and summarize how we addressed these questions in our research.

#### **1. Can a robust web-based expert system that provides useful information be created for PLWHA?**

We initially carried out a literature review which showed that expert system has successfully been created and used to disseminate medical information to both patients and HCWs. In the area of HIV, advisory expert system using web interfaces has been developed and used to disseminate general information about HIV to patients, remind patients to take the ARVs drugs and also inform patients on the stage of HIV they are in by performing a CD4 count. These systems prove that expert systems can store large amounts of information and they have the potential to expand with increase of information.

The next step was to determine the capacity of the HCWs and patients in terms of technology. In exploring pragmatic design solutions that “do not require adding more technology or infrastructure to a situation” (Winchester et al. 2009), we targeted the mobile phone as a medium to access the system. We were able to establish that most of the patients access the internet via their mobile phones. The mobile phone offers an ideal medium that allow the patients to access information any time and at any place.

After receiving positive response from the users, we needed to tailor the system such that met the specification and needs gathered from management, HCWs and the patients. The system had to be robust and immune to uncertainties. Through interviews, document ethnography and observations we were able to gather substantial information that we fed into the system. We developed the system according to the users’ specifications. The system was developed iteratively. We presented the system to the HCWs to test it for errors. Errors found were fixed and the system was tested further until it was functioning perfectly.

Our system proved to be robust, practical, easy to use and it provided accurate information. Throughout the evaluation process, there were several tests which were carried out to evaluate the robustness of the system. The robustness of the system’s interface was tested. The interface was bombarded with valid and exceptional inputs. The system only accepted the valid information. The system did not allow users to use the system before they read and accepted the terms and conditions. The user had to fill all the required fields in order to access the information. The system did not crash or hang during the querying process thus proving to be robust. Scalability testing was also carried out. The system was initially fed with large amounts of information and the HCWs continued adding information to it on a weekly basis. The system was able to handle all the information that it was fed with thus proving to be scalable. The security of the system was also tested. The system only allowed the four HCWs to alter the information stored in the system. The system restricted access to authorized HCWs. This ensured that the information was secured and kept up-to-date. A stress test was also carried out on the system. Since the system was going to be accessed by many people, we had to ensure that it could handle numerous queries at ago. This test was carried out during the heuristic evaluation. The system was accessed by numerous people at the same time and it provided the appropriate information. All these tests were carried out to measure the robustness of the system.

The system worked perfectly, and after the six months, we were able to collect users' data. It had the capacity to hold large amounts of information. It also stored the records of all the patients that accessed it. The system was simple and the HCWs could use the system effectively without further training.

## **2. Can the system be kept up-to-date to ensure that PLWHA receive accurate information?**

We trained the HCWs at the clinic how to add, edit and delete information from the system. The HCWs were provided with usernames and passwords that allowed them to alter the information in the system. The aim of this training was to ensure that the HCWs kept the system information up-to-date.

Figure 5.8, 5.9 and 5.10 shows that the HCWs kept the information in the system up-to-date. They added new information to the system on a weekly basis. They also edited information in the system to ensure that the information in the system was accurate. Some information was also deleted from the system. This included the use of spices and herbal medicine remedies. The information was accurate and HIV-patients could access it to self-manage the HIV-related symptoms.

Through the interview that was carried out with the PLWHA, they informed us that the information which they accessed was equally relevant and accurate to the one they were being provided during the counseling sessions in the clinic.

## **3. Can the system enhance the PLWHA to self-manage the HIV-related symptoms thus improve their quality of life?**

We monitored the system logs for six months. Figure 5.6 shows the number of logs in to the system. From the logs, it is vivid that the patients accessed the system throughout the six months period. They accessed the system to get remedies for various HIV-symptoms. We later conducted an interview with the HCWs and patients at Gugulethu clinic. The HCWs informed us that the trips to the patients' homes had reduced since the patients had learnt to use the system to self-manage the HIV-related symptoms. The HCWs said that the system has helped most HIV-patients especially women and children.

During the interview with PLWHA, we received positive remarks from them. “I have learnt how to handle my lack of appetite issue,” said one of the patients. She said that, for a long time, she had suffered from lack of appetite and her body weight had reduced drastically. She said that she was now taking the ARV drugs and using different home remedies that the system provided to manage her lack of appetite and this had helped her improve her health. Another patient said that her child could not take the ARV drug because they were bitter. The system advised her to coat the medicine with sugar which has made it easy for her child to administer the drugs. Other patients who frequently accessed the internet said that the system acts like a reminder for them to take their ARV drugs.

However, despite the patients complaining of the high cost of internet from local mobile service providers, they appreciated the simplicity and usability of the system. They confirmed that the system had helped them improve their livelihoods. The system is still in use to date and the patients are accessing it.

### **6.3 Experience of Working in Gugulethu Clinic**

Working with Gugulethu clinic staff was a great experience. Most of the patients were predominantly Xhosa. This was a challenge to us since we could only communicate in English. The HCWs acted as the interpreters thus enabling us to communicate with the patients at ease.

At first, the HCWs at the clinic were not friendly. This is because they had not understood the aim of our research. Initially we dealt with HCWs who did not know how to use computers. The head of the HIV unit at the clinic linked us with one of the HCWs who could operate computers. She understood the aim of our research and embraced the idea. She was cooperative and she took the responsibility of informing other HCWs on the aim of the system.

Communication with the HCWs became easier. We mainly used emails and whatsapp messenger to communicate. They would alert us when to attend the counseling sessions at the clinic. During the system implementation period they provided valuable information that was included in the system. They also communicated with us whenever they made changes to the system knowledge base.

The management team at the HIV-unit at Gugulethu clinic was supportive. They embraced the research idea and they worked with us to ensure that it was a success. We created a great

relationship with them and sometimes they would drive us back to campus after a busy schedule at the clinic.

There was a sense of satisfaction to know a group of people and having a visible impact on the way they work.

## **6.4 Contribution**

Among the eight Millennium Development goals (MDGs) that the South African government signed with the United Nation is “*To combat HIV/AIDS, malaria and other diseases*”(Statistics South Africa 2010). The Government of South Africa has intensified the implementation of policies, strategies and programs aimed at combating HIV and AIDS. To combat HIV/AIDS, we used ICTs to disseminate information to HIV-patients. The information helps the patients to self-manage the HIV-related symptom which they experience. The system also reminded the patients to always use the ARVs drugs.

We found that our web-based expert system was an appropriate technology for Townships and rural community patients in South Africa. The system can be used where there are few HCWs, clinics are far, or in cases where the patients can not afford fare to the nearest clinic. In such contexts, the advisory expert system can be used to provide information that can relieve pain related to the HIV-related symptoms. In a state where the patient can not access the system due to the illness, care takers can access the system and provide the remedies to the patients.

This work sought to prove that ICT is a powerful tool that can be used to reach a large number of patients thus enabling them to easily access information which they would otherwise receive by visiting health care sites. ICT4D projects can be used to elevate patients’ livelihood. They need to emphasis on empowering underprivileged people to readily access professional help using tools such as mobile phones whose penetration is increasing in developing countries.

Finally, we have shown how simple technology can be used to help patients in less privileged areas. We have shown the importance and relevance of using user center design in developing the system. We have demonstrated how we can use formative, explorative field studies to enrich our dialogue with users and understand their needs from which we can draw valuable implications to localize and shape designs.



## **6.5 Sustainability**

Sustainability is an important aspect, especially in an ICT4D context where systems are successfully implemented and used at an early stage but quickly fade away once the research is over.

To ensure that the system was sustainable, we trained the HCWs on how to modify knowledge in the system. The HCWs help each other to learn the system and to manage the information it stores. Training manuals were also developed and attached to the system to ensure that the users learn how to use the system even without going through a training session.

We have also maintained contacts with the clinic management and the HCWs. Whenever there is a system breakdown we offer technical assistance.

## **6.6 Future Work**

An interesting avenue of future work would be to pursue one of the original ideas of the research, specifically to use Unstructured Supplementary Service Data (USSD) provided by the mobile service providers to query the expert system for information. This would allow users to use any type of phone to access the medical information. This would also cut the high internet cost involved.

Additional work which could also be done is providing an interface where patients can communicate with HCWs via the system. The patients can air their views without visiting the clinic. The online communication is recorded and later tackled when the patients attend the weekly meetings.

Another issue noted during our interviews which should be incorporated in the system was the need for reminders to alert the patients that the HCWs will be visiting their homes to extend the home-based care. The HCWs reported to us that sometimes they would visit the patients' home and would not find the patients. The patients should register with the clinic and a unique

registration provided to them. The system could use the unique number to send the patients a short message that alerts them that the HCWs will be visiting them at home. This could make the home-based care more effective. This was one of the initial ideas of the system but, due to time constraints, it has created an opportunity for future work.

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## **Appendices**

The following are the appendices referenced in the body of the text of this thesis.

## **Appendix A**

This appendix shows the interview questions asked, during the feasibility study.

### **Interview Questions and response that we recorded.**

- **What are the challenges that HIV+ patient who receive home care face?**
  - Some patients do not have the strength to come to the clinic for treatment and they have to wait for us to visit them at their home for assistance
  - Some live far from the clinic and they do not afford the fare to the clinic
  - The number of patients is far much higher than the number of the health care workers in the clinic. The Health care workers do not manage to visit all the patients at their home as it is required.
- **Do patients in this area have access to the antiretroviral drugs?**
  - “Yes, the government of South Africa provides free antiretroviral drugs to all the HIV patient”
- **If yes how do they access it?**
  - “We have a record of all HIV patients who visit this clinic for treatment and counseling. When they reach the second stage of HIV, the patients are introduced to the drugs. We remind them to come to the clinic to come collect the drugs. We also have their care givers contact who sometimes collect the drugs on their behalf”
- **What are the challenges PLWHA faces in accessing these drugs?**
  - “The drugs are readily available at the clinic. All they need to do is to collect them from the clinic. Though sometimes PLWHA are attacked by thieves, and their drugs are stolen.”
- **Are there patients who do not adhere to the medication?**
  - “Yes there are some patients who do not take their medication. To ensure that they take all the drugs, the health care workers visit the patients regularly at their homes and perform pills count. If the count shows that the patients have not been taking their

medication, the Health care workers hold a counseling session with them and advise them on the benefits of the drugs.”

- **What else do you advise the patients to use to manage the disease?**
  - “We advise the patients to use the readily available home remedies in their households to self-manage the HIV-related symptoms which they experience. The home remedies do not include spices or herbal medicine. They should avoid these. We also educate them to use the remedies co-currently with the ARVs.”
- **Are there community health care workers available in this clinic?**
  - Yes, the clinic has recruited some health care workers who attend to the HIV patients. Some people from the township also volunteer to work at the clinic. They visit the patients at their homes and advise them on positive living. The only problem is that they frequently leave the clinic because they are not paid thus the number of health care workers in the clinic is still low.
- **In absence of help from the community workers, how do the patients handle their HIV-related symptoms?**
  - They use the appropriate home remedies they have been advised to use to manage the symptoms which they experience.
- **How does nutrition benefit PLWHA?**
  - It prevents malnutrition
  - Improve the health nutritional status of the patients
  - Good diet slow the progression of the disease
- **How do the patients receive nutritional advice?**
  - We hold training session every Mondays and Saturdays at the clinic. The patients are trained on the benefits of eating healthy. We also have a nutritionist at the clinic who counsel individual patients whose health has deteriorated due to poor nutrition. Lastly the health care workers visit the patients at their home and provide them with nutritional advice and psychological support.
- **Are there systems which are being used to help the patients in this clinic?**
  - There is only one system that was implemented in this clinic. It is called ‘mind-health’ but it is no longer in use in the clinic.

## Appendix B

This appendix shows the symptoms stored in the system (tbl\_symptom).

Symptom	Date	Edit	Delete
<a href="#">Nausea and Vomiting</a>	2012-06-06 12:15:17.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Lack of appetite</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Coughing</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Constipation</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Chills</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Itchy skin</a>	2012-06-06 21:53:20.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Burning with urination</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Wheezing</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Sore throat</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Mouth thrush</a>	2012-06-06 21:53:31.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Prominent leg veins</a>	2012-06-06 21:56:41.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Sore/Bleeding gums</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Mouth ulcers</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Nose bleeds</a>	2012-06-06 21:53:46.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Bloating</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Stomach area Weight gain</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Sinus Inflammation</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Insomnia/lack of sleep</a>	2012-06-02 21:51:41.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Stress</a>	2012-06-02 21:46:26.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Thirsty</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Diarrhoea</a>	2012-06-01 11:56:14.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Fever</a>	2012-06-02 21:46:10.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Phlegm</a>	2012-07-23 15:48:14.0	<a href="#">Edit</a>	<a href="#">Delete</a>
Showing 1 to 23 of 23 entries			
First Previous 1 Next Last			

## Appendix C

This appendix shows the symptoms remedies stored in the system (tbl\_remedies).

Symptom	Remedy	Date	Edit	Delete
<a href="#">Lack of appetite</a>	<a href="#">Try different food.</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Chills</a>	<a href="#">prepare and take chicken soup regularly</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Sore throat</a>	<a href="#">Crush lemon and mix it with ginger and take a large spoon of the mixture.</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Mouth thrush</a>	<a href="#">Avoid sweet and sour food.</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Bloating</a>	<a href="#">Dont drink too much with food.</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Sinus Inflammation</a>	<a href="#">Use salt water rinse for the nasal passage</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Stress</a>	<a href="#">Use lemon grass as tea.</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Thirsty</a>	<a href="#">Drink a lot of water</a>	2012-04-09 19:21:52.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Constipation</a>	<a href="#">Exercise regularly</a>	2012-04-11 22:43:27.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Nausea and Vomiting</a>	<a href="#">Sit up when eating.</a>	2012-05-08 22:03:59.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Nausea and Vomiting</a>	<a href="#">Try not to prepare the food yourself.</a>	2012-05-08 22:04:54.0	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Nausea and Vomiting</a>	<a href="#">Eat dry and salty food.</a>	2012-05-08 22:05:41.0	<a href="#">Edit</a>	<a href="#">Delete</a>

## Appendix D

This appendix shows the different administrators that modified the data in the system to make it up to date (tbl\_useractivity).

+ Options					
		username	password	enabled	emailaddress
<input type="checkbox"/>	<a href="#">Edit</a>	admin	a564de63c2d0da68cf47586ee05984d7	1	chrissyshiru@gmail.com
<input type="checkbox"/>	<a href="#">Edit</a>	pmungai	a564de63c2d0da68cf47586ee05984d7	1	wandopm@gmail.com
<input type="checkbox"/>	<a href="#">Edit</a>	guest	a564de63c2d0da68cf47586ee05984d7	1	guest@localhost.com
<input type="checkbox"/>	<a href="#">Edit</a>	chrissyshiru	a564de63c2d0da68cf47586ee05984d7	1	chrissyshiru@google.com
<input type="checkbox"/>	<a href="#">Edit</a>	92829202	098f6bcd4621d373cade4e832627b4f6	1	test@test.com
<input type="checkbox"/>	<a href="#">Edit</a>	888888	e10adc3949ba59abbe56e057f20f883e	1	test1@google.com
<input type="checkbox"/>	<a href="#">Edit</a>	999999	ab56b4d92b40713acc5af89985d4b786	1	test2@google.com
<input type="checkbox"/>	<a href="#">Edit</a>	0734596979	6dfdc384d6025b2ab9b71ec15971aa11	0	cjrr@gmail.com
<input type="checkbox"/>	<a href="#">Edit</a>	0724843764	99f16a6c8d12e4f6fcc1151d398ef97f	1	abc@gmail.com
<input type="checkbox"/>	<a href="#">Edit</a>	mpahlenia	3c0a026afbe5b8d28dff8ed051321149	1	mpahlenia@gmail.com

## Appendix E

This appendix shows the data stored of the date, time and the information access by anonymous users. (tbl\_biodata).

<input type="checkbox"/>					18	Female	16-25	2	Years	Grade 8	Y	2012-05-1
<input type="checkbox"/>					19	Female	16-25	2	Years	Grade 8	Y	2012-05-1
<input type="checkbox"/>					20	Female	16-25	3	Years	Grade 8	Y	2012-05-1
<input type="checkbox"/>					21	Female	16-25	3	Years	Grade 12	Y	2012-05-1
<input type="checkbox"/>					22	Female	16-25	3	Years	Grade 12	Y	2012-05-1
<input type="checkbox"/>					23	Female	36-45	3	Years	Grade 12	Y	2012-05-1
<input type="checkbox"/>					24	Female	36-45	2	Years	Grade 12	Y	2012-05-1
<input type="checkbox"/>					25	Female	26-35	3	Years	Grade 8	Y	2012-05-1
<input type="checkbox"/>					26	Female	56-65	3	Years	Grade 12	Y	2012-05-1
<input type="checkbox"/>					27	Female	46-55	3	Years	Grade 8	Y	2012-05-1
<input type="checkbox"/>					28	Female	26-35	4	Years	Grade 8	Y	2012-05-1
<input type="checkbox"/>					29	Female	36-45	0	Years	Grade 12	Y	2012-05-2
<input type="checkbox"/>					30	Male	16-25	0	Years	Grade 8	Y	2012-05-2

☐ Check All / ☐ Uncheck All With selected: Change Delete Export

Page number:

Show:  row(s) starting from row #  in  mode and repeat headers after

				id	gender	age	symptomDuration	educationLevel	terms_conditions	datetime
dit				31	Female	26-35 Years	0	Grade 8	Y	2012-05-21 08:01:20
dit				32	Female	26-35 Years	3	Grade 8	Y	2012-05-21 08:02:57
dit				33	Female	16-25 Years	2	Grade 12	Y	2012-05-23 13:02:03
dit				34	Female	26-35 Years	3	Grade 8	Y	2012-05-23 15:33:49
dit				35	Female	26-35 Years	2	Grade 5-8	Y	2012-05-24 02:14:57
dit				36	Female	16-25 Years	0	Grade 5-8	Y	2012-05-24 02:24:07
dit				37	Female	26-35 Years	2	Grade 5-8	Y	2012-05-24 02:24:16
dit				38	Female	16-25 Years	0	Grade 5-8	Y	2012-05-24 02:25:36
dit				39	Female	26-35 Years	2	Grade 5-8	Y	2012-05-24 06:47:29
dit				40	Female	16-25 Years	3	Grade 5-8	Y	2012-05-24 09:21:54
dit				41	Male	1-15 Years	2	Grade 1-4	Y	2012-05-24 09:29:22
dit				42	Female	16-25 Years	1	Grade 5-8	Y	2012-05-24 10:28:37
dit				43	Female	26-35 Years	3	Grade 9-12	Y	2012-05-30 08:14:45
dit				44	Female	1-15 Years	1	Grade 1-4	Y	2012-05-30 08:21:38
dit				45	Male	26-35 Years	3	Grade 9-12	Y	2012-05-30 20:31:40
dit				46	Male	26-35 Years	2	Grade 9-12	Y	2012-05-30 21:06:02
dit				47	Female	16-25 Years	3	Grade 5-8	Y	2012-05-31 11:21:21

dit				43	Female	26-35 Years	3	Grade 9-12	Y	2012-05-30 08:14:45
dit				44	Female	1-15 Years	1	Grade 1-4	Y	2012-05-30 08:21:38
dit				45	Male	26-35 Years	3	Grade 9-12	Y	2012-05-30 20:31:40
dit				46	Male	26-35 Years	2	Grade 9-12	Y	2012-05-30 21:06:02
dit				47	Female	16-25 Years	3	Grade 5-8	Y	2012-05-31 11:21:21
dit				48	Female	26-35 Years	2	Grade 5-8	Y	2012-05-31 11:25:44
dit				49	Female	16-25 Years	0	Grade 5-8	Y	2012-05-31 11:30:12
dit				50	Female	26-35 Years	2	Grade 5-8	Y	2012-05-31 11:32:14
dit				51	Male	16-25 Years	2	Grade 5-8	Y	2012-05-31 11:32:42
dit				52	Female	26-35 Years	3	Tertiary level	Y	2012-06-01 05:15:28
dit				53	Male	1-15 Years	2	Grade 1-4	Y	2012-06-01 07:05:12
dit				54	Female	16-25 Years	3	Grade 5-8	Y	2012-06-01 07:08:22
dit				55	Female	26-35 Years	2	Grade 5-8	Y	2012-06-01 11:41:15
dit				56	Female	16-25 Years	2	Grade 5-8	Y	2012-06-01 11:59:04
dit				57	Female	26-35 Years	1	Grade 5-8	Y	2012-06-01 12:02:25
dit				58	Female	1-15 Years	1	Grade 5-8	Y	2012-06-01 17:48:19
dit				59	Female	36-45 Years	3	Grade 9-12	Y	2012-06-02 09:38:59

## Appendix F

This appendix shows the ethical clearance we received from the faculty of science

Department of Environmental and Geographical Science  
University of Cape Town  
RONDEBOSCH 7701  
South Africa

e-mail: [Michael.meadows@uct.ac.za](mailto:Michael.meadows@uct.ac.za)  
phone : + 27 21 650 2873  
fax : +27 21 650 3791



19<sup>th</sup> August 2012

Mr Julius Kanjere  
Department of Computer Science  
University of Cape Town  
[chrissyshiru@gmail.com](mailto:chrissyshiru@gmail.com)

Dear Ms Wanjiru

### **Advisory Expert System for HIV/AIDS Patients: Case Study**

I am pleased to inform you that, having scrutinized the details of your above-named application for research ethics clearance, the Faculty of Science Research Ethics Committee has approved it in terms of its attention to ethical principles.

Your approval code is: SFREC 29\_2012

I wish you success in the work involved.

Yours sincerely

Michael E Meadows  
Professor and Head of Department  
Chair: Science Faculty Ethics in Research Committee